

THE INTERNATIONAL **ELECTRONICS** MAGAZINE

June 1996

£ 2.65

Focus on:
Digital video recorders

ELEKTOR ELECTRONICS

**FLASH EPROM
PROGRAMMER**
(and EPROM emulator)

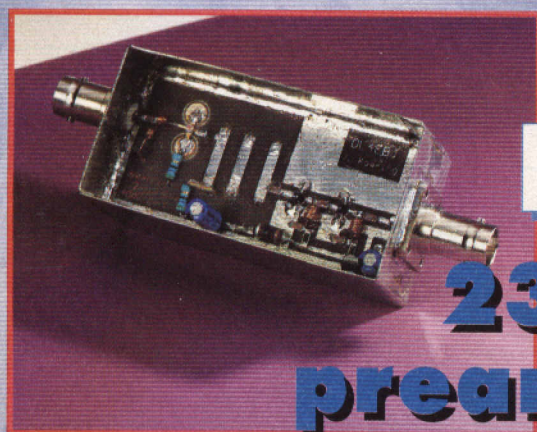
**23 CM ATV
PREAMPLIFIER**

**STOP THAT
BARKING!**



Flash-EPROM programmer

32

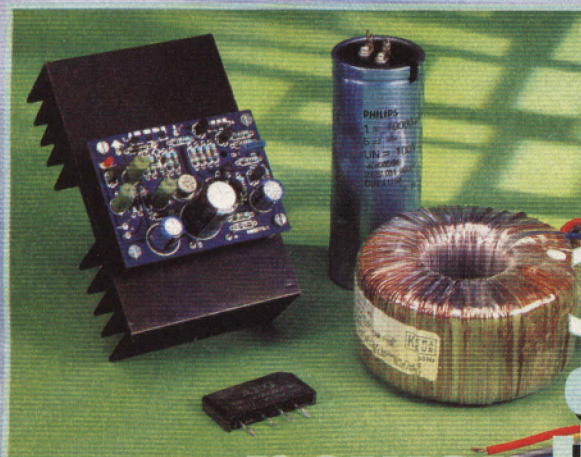
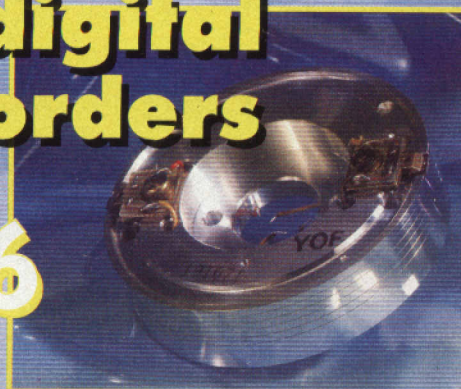


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35 active power buffer

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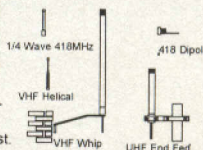


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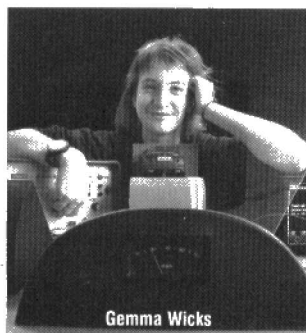
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YOUNG ELECTRONIC DESIGNERS SHOW THEIR PACES

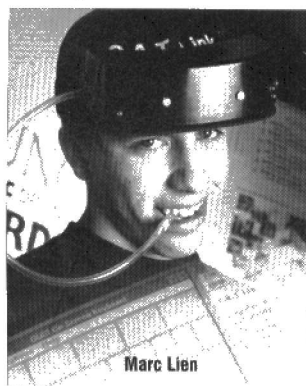
As in previous years, the finals of the Young Electronic Designer Awards, held at the Science Museum in London recently, showed the creativity and the imagination of young British designers in electronics.

As before, the competition, sponsored by Mercury Communications Ltd and Texas Instruments, in association with the Institution of Electrical Engineers (IEE), was open to students between the ages of 12 and 25 years from secondary school, colleges and universities. The competition challenges young designers to invent and produce novel electronic devices that meet an everyday need.



Gemma Wicks

Winning the Duke of York's Award for Creative Technology was Gemma Wicks, a 15-year old from Bancroft's School, Wood Green, Essex, who devised a system for displaying the stopping distances for vehicles. Gemma, whose project had already won the Young Engineer Award's Silver Crest at the British Youth Science Fair, held at G-Mex, Manchester, recently, is a member of an electronics club at her school and discovered the need for the project when her friend was learning to drive.



Marc Lien

Receiving the Mercury Planet Award of £2,500 for school and student for the most socially or environmentally aware project was Marc Lien, an 18-year old student formerly from the Mer-

chant Taylors School, Northwood, Middlesex, whose project was a quadriplegic computer aid. Marc, while taking a level Maths, Physics and Design Technology, designed a remarkable piece of hardware and software, which enables the disabled to control a computer by head movements and also to replace the use of a mouse by blowing through a tube.

Marc came upon the idea for the project while working with the section of society now known as PHABS—Physically Handicapped Able-Bodied—as part of his schooling. Marc told *Elektor Electronics*: "I came to realize just how difficult it was for many of them to use an ordinary computer".

For the project, a major part of his Design and Technology A level work, Marc created a headset with a series of electronic sensors that follow head movements; the software, which he wrote in assembler language; and a computer keyboard on the screen. His software will even allow the computer to do the talking for PHABS.

The project has been field-tested and already several commercial companies have expressed an interest.

Taking the Texas Instrument prize of £2,500 for school and student for the most commercially viable project was 15-year old Christopher Caulkin, a fourth-year student from Radley College, Abingdon, Oxfordshire, who is taking electronics at GCSE level.

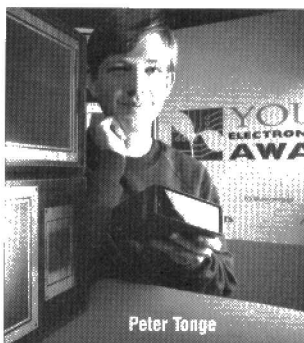
Christopher's device, a microcontroller-based instrument for controlling sunbathing was the result of a painful experience in the sun.

Christopher told *Elektor Electronics*: "I was looking for a project which would be a solution to a problem and not a solution looking for a problem. People nowadays spend more and more time in the sun and as a result we need a system that tells them when to cover up. The safety device provides a simple and attractive solution against sunburn and the potentially resultant skin cancer." [In western Europe, each year more than ten thousand people die from skin cancer, in many cases caused by sunbathing. Editor]

"It is very simple to use, merely requiring the user to select his/her skin tone and the strength of the sunscreen applied. This is selected by pressing

the relevant button until the required value is shown on the screen. The safe tan device is then set and will beep when it's time for the sunbather to get out of the sun. If he/she decides to go indoors for any reason, the device can be stopped by a pause button. The device even turns itself off automatically after it has warned the user to go indoors. It can also be switched off manually by pressing and holding a switch for three seconds. There is a power saving sequence if the device is left untouched for more than thirty seconds: this ends when any button is pressed. The display constantly updates the recommended time the user has remaining. It is small, light and convenient, and operates from standard batteries."

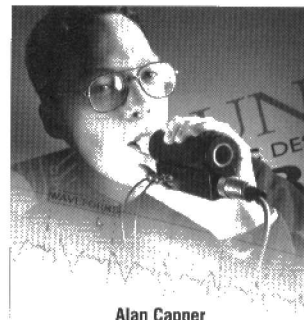
In electronic terms, the device uses one linear TI light sensor, three pcb mounted push-button switches; a buzzer; a dual high brightness 7-segment LED display, and a Type PIC16C73XS microcontroller. Power is derived from three series-connected AAA batteries. The device cost about £15 to build, but Christopher believes that this would be halved for production quantities of 100 and over. He estimates the market potential in the UK alone at 10 million. Needless to say, Christopher has already applied for a patent for his device, while a number of commercial organizations have expressed an interest in it.



Peter Tonge

Peter Tonge, a 16-year old from Bolton School, took the IEE Award of £1,000 for school and student for the best new entrant to yeda with his audio preamplifier. Peter, who is taking his GCSEs, including Technology, this summer, decided to solve the problem of how to control the volume of a video recorder and a hi-fi unit at the same time. He told *Elektor Electronics*: "The most difficult part was the decoding of the TV remote controller."

Winning the YEDA trophy and £1,000 for the Senior Category (18–25 years) was Alan Capper, a 22-year old student from the University of Wales, Bangor, whose project was dubbed



Alan Capper

'TED'—The Electronic Doctor. This is a system that allows the duty GP to remotely monitor a patient's vital signs by telephone, that is, tele-medicine, before deciding whether to visit, call an ambulance or give other advice.

TED uses only four electronic sensors housed in an easy-to-use hand-held unit, to measure seven or more parameter directly, including temperature, respiratory rate, breathing sounds, ECG, blood oxygen level, blood pressure and pulse rate. Other parameters are derived mathematically by the GP's computer.

Alan said: "The aim of the project is to provide the GP with a range of relevant information that can be readily viewed, manipulated and recorded, on a laptop computer in the form of sufficient quality to enable a reasonable, preliminary diagnosis to be made. Its purpose is to filter unnecessary night-time calls, thereby reducing the load on GPs who are becoming increasingly disillusioned with their increased work load. By providing TED with a dedicated computer interface and software, data can be validated by inspection and complete records created without effort."

Coming second in the Senior Category was Marc Lien with his quadriplegic computer; and third was Louise Jens, 22, from Brunel University, Uxbridge, Surrey, with her universal remote controller.

Highly commended in this category were Ben Curren, 18, from Bolton School, with his remote control light filter changer for stage lighting; Matthew Wilson, 22, also from Brunel University for his unit to adapt a video recorder to record teletext subtitles with programmes; and Andrew Lyness, 18, from Ballyclare High School, Ballyclare, Northern Ireland, for his fully integrated electrical guitar and amplifier effects project.

In the Intermediate Category (15–17-year olds), first prize went to Christopher Caulkin for his microcontroller sunbathing warning device. Second prize was for Andrew Gough, 17, from

Events

May

21-23: *The Internet World Exhibition in London.*

30-2 June: *The Home PC Show. For details, phone 0181 849 6200*

June

2: *Northern Mobile Amateur Radio Rally at Ripon Race-course*

Open: 11:00 am

Talk-in on S22 from 09:30 am

Follow signs to Ripon Race-course from A61 Ripon By-Pass.

Details: phone 01765 640229

4-5: *The ICET 96 conference on electronics technologies in Brighton, UK.*

18-20: *Multimedia 96 at the Business Design Centre, London. For details, phone 0171 359 3535*

30: *The 39th Longleat Amateur Radio Rally*

Open 10.00 am to 1700 pm.

Free car parking

150 trade stands

20 local and national club stands

Adults £2.50

Senior Citizens £2.00

Children 50p

Follow the brown tourist signs for 'Longleat House' (Not Safari Park) from the A36 near Warminster, Wiltshire. Details: phone 0117 940 2950

July

16-18: *The Semicon/West 96 exhibition and conference in San Francisco.*

September

2-8: *The Farnborough Airshow at Farnborough, UK.*

October

8-10: *The Euro-EMC exhibition at Sandown, UK.*

18-27: *The Connect 96 consumer electronics show at the NEC, Birmingham.*

November

12-15: *The Electronics 96 exhibition in Munich, Germany.*

26-28: *The Manufacturing Week Exhibition at the NEC, Birmingham.*

December

8-11: *The International Electronic Devices Meeting in San Francisco.*



Portadown, Northern Ireland, for his audio multimeter; and third prize went to Paul Caulter, 17, from Ballyclare High School, Ballyclare, Northern Ireland, for his Automatic Temperature Embedded Sensing Equipment—ATESE.

Highly commended in this category were Rebecca Largo, 15, Shama Chaudhry, 15, Joanne Stagg, 16, and Bevan Davies, 15, for their electronic device to aid young children with mathematic system. Also highly commended were Peter Tonge with his audio preamplifier, and Gemma Wicks for her head-up stopping display for vehicles.

Topping the Junior (under-15) Category for a YEDA trophy and £500 for school and student was David Kelnar, a 14-year old from Merchiston Castle School, Edinburgh, who devised an accessible, multi-media educational system, creating both the hardware and the software.

Second in this category was Timothy Short, 14, from Sevenoaks School, Sevenoaks, Kent, for his programmable windscreen wiper controller. Third place was for James Anderson, 14, from Radley College, Abingdon, for his finder unit to aid the blind.

Highly commended in this section were Eileen Parks, Gayle Doulton and Natelia Smith, all 14 and from Ballyclare High School, Ballyclare, Northern Ireland, for their electronic Fast Unfreezing Nozzle (FUN for short). Also highly commended were Claire Palmer, 14, from Bancroft's School, Wood Green, Essex, for an electronic device to alert a driver that the vehicle in front is braking heavily; and Karen Scholes, 14, from Ridley High School, Blyth, Northumberland, for her blood-sugar level tester for diabetics.

Despite YEDA being in its tenth year, there is no evidence that the innovation and creativity of young electronic designers in the United Kingdom is showing any waning. During the course of its ten-year history, YEDA innovations have included

a hand-held electronic meter probe to measure brake fluid contamination for use in service stations; the beam music, a series of infra-red light beams that are broken by hand movements and sensed by a computer-controlled keyboard which generates music notes; a safety iron for hand-

icapped or visually impaired people; an electronic hand-held anemometer/wind speed measuring device with no moving parts.

Details of the YEDA Scheme may be obtained from The YEDA Trust
24 London Road
Horsham
West Sussex RH12 1AH
Telephone 01403 211048
Fax: 01403 210770.

ELECTRONIC CERAMICS NOW AND THEIR FUTURE

Novel machining techniques and recent developments in more precisely controlled conventional machining, achieving accuracies in component parts of within 50 nm, has led to significant progress in the use of ceramics in a bid to reduce the size and increase the response speed of electronic circuits.

For some time, ceramics have been widely employed in many electrical and electronic components such as insulators, conductors, resistors, capacitors, and sensors.

Reducing stresses

However, the more complex and highly developed electronic devices, involving high density packaging for example, will demand ceramics that exhibit thermal expansion in line with silicon so that thermal stress are reduced, a uniform low dielectric capability for signal processing enhancement, and superior thermal conductivity to disperse the heat from integrated circuits.

Such materials as alumina, beryllium oxide, aluminium nitride, silicon nitride, mullite, zirconia, and ferrite, meet many of these criteria, with alumina probably being the most widely used. Several oxide compositions, mainly silicon oxide, some glass-ceramics as well as silicon nitride, have been developed as thin-film insulators for integrated circuits. Modified lead magnesium molybdate, which exhibits high dielectric content among its properties, is being used for disc, multilayer and thick-film capacitors, while lead zirconate-titanate formulations are the primary materials for ferroelectric thin films employed in memory applications.

Significant development

One of the most significant developments in machining tech-

niques has been developed at Warwick University where the object of reducing spacing between conductor tracks has been furthered by laser drilling. The lasers have been employed in drilling green-state dielectrics to produce high-density interconnections for microelectronics systems. They are used to drill vertical holes in layers of multi-layer dielectric where layers of conductors, voltage reference planes, decoupling capacitors, resistors, and so on, are separated by layers of dielectric. The holes are then filled with conductor materials to form 'vias' for connection to the printed circuit on each layer.

The drilling is carried out in the green state of the dielectric which is produced by standard thick-film techniques. To satisfy the particular requirements of the dielectric, various combinations of glass and glass-ceramic materials were subjected to the laser-drilling process and to subsequent sintering. Tests show that the optimum combination included a medium softening point glass-ceramic and high softening point glass which underwent crystallization during the sintering process.

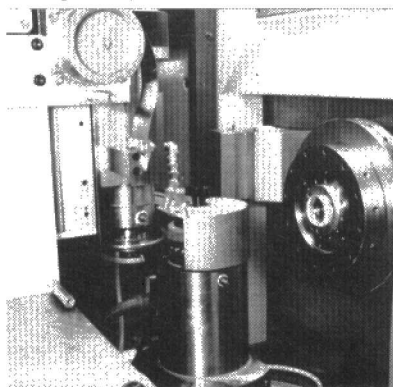
This technique provides for small vias of 50-60 µm to be achieved with a carbon dioxide laser using only a small number of steps and conventional screen-printing technology. The laser drilling process is selective as only the dielectric is drilled because absorption characteristics are matched to the laser wavelength. It is also self-limiting because the underlying metal conductor reflects the laser light.

Super abrasives

Laser optics have also been developed to drill thin film organic dielectrics with excimer lasers.

With the more conventional approach to high-precision grinding of advanced ceramics, the so-called 'super abrasives' are usually preferred for the appropriate cutting and grinding processes. Cubic boron nitron (cbn), for instance, is harder and more wear-resistant than conventional abrasives such as aluminium oxide and silicon carbide.

Although cbn resists chemical attack by iron, cobalt and nickel, diamond is the super abrasive generally best suited for grinding ceramics formulations. Among the latest of the more conventional type machines using diamond abrasive is an ultra-stiff, computer numeric controlled (cnc) aspheric generating grinding machine developed by Cranfield Precision Engineering. Known as the nanocentre, the machine is a new ultra-precision cnc aspheric generator.



Detail of the Nanocentre at Cranfield Precision Engineering.

Excellent stability

It features high loop stiffness, thus ensuring efficient ductile regime grinding of a range of brittle materials on components up to 600 mm diameter and 250 mm axial length and to accuracies of within 50 nm. The Nanocentre – a six-axis diamond turning and ductile regime grinding machine – is bedded in granitan S100, a synthetic granite, to give excellent dimensional stability, high specific stiffness and high internal damping.

Further stability needed for precision machining of ceramic components is provided by supporting the base on a three-point, self-levelling pneumatic isolation system that stands on a large, damped-mass, concrete foundation. The nano-grinding facility for this machine was designed to exploit the latest technological advances in grinding of glass, ceramics, and other hard materials.

To achieve this, the highest possible loop stiffness, a critical factor in ductile-mode machining

of brittle materials, was incorporated. These capabilities mean that the machine can take the real sub- μm cuts that are essential for accuracy while minimizing sub-surface damage.

A major manufacturer and supplier of advanced technical ceramics for the microelectronics industry is Coors Ceramic Electronics. Among the company's products are ceramic substrates for microelectronic circuitry, laser-machined substrates, dry-pressed ceramics, and metallized ceramics.

To meet the needs of electronic packaging, the company offers 92 per cent alumina, alumina nitride, and low-temperature cofire glass ceramic. Coors manufacturing processes include continuous tape casting, dry pressing, roll compaction, and extrusion, involving alumina, zirconias, and other advanced ceramics. Laser machining and numerically controlled punching of substrates, refractory metalizing, lapping polishing and grinding of ceramics, and applying epoxy to ceramics are among the processes undertaken by the company.

The future

But what of the future? It is considered that 5 nm line widths of gold on silicon substrates is theoretically possible. This next generation of electronic devices is called static induction transistors (sit). However, that is not all. A major potential competitor to the electronic sit is the optical (photonic) transphaser. This optical system promises switching speeds of, perhaps, a few ps. Unlike the electronic transistor, it could also be capable of more than two stable states, a potential that would revolutionize present-day computing logic.

Photon transmission technology could eventually achieve better performance than the indium antimonide, gallium arsenide, and zinc selenide, used in many research programmes. These and other exciting developments involving new specialized ceramics will put even greater demands on a new generation of precision engineering machines.

[lps – 356/5]

ESR CATALOGUE

The new 1996 PCB Production Catalogue from ESR Electronic Components is sure to be of interest to most readers. It is fully illustrated and covers all aspects of

printed-circuit board (PCB) production for hobby, education and professional use. It is ideal for small volume and prototype work.

The catalogue carries all that is required to take an idea on paper, from a simple prototype on breadboard, matrix board or stripboard through to a PCB layout, and finally to a professional looking pcb. All materials, chemicals, equipment, tools, and safety equipment, are included.

Contents include Development, Drafting materials, PCB laminates, PCB equipment, Chemicals, Tools, and Health and Safety. Many new products are included, all competitively priced, making this catalogue a comprehensive one-stop source for PCB production.

For a free copy, send an A4 SAE (with 47 p of stamps). Also sent free when requested with any order over £ 7.50. ESR Electronic Components, Station Road, Cullercoats, Tyne & Wear, NE30 4PQ. Telephone 0191 252 4363; Fax 0191 252 2296.

TROUBLE WITH AUDIO PARTS?

In the UK: many high-precision resistors (1%, 0.1% and 0.01%) are available ex standard stock from Rhopoint Components. The resistors include wirewound, metal foil, power film, and manganin foil types.

Full design-in information is available from Rhopoint Components, Holland Road, Hurst Green, Oxted, Surrey RH8 9AX, England. Phone 01883 717 988; fax 01883 712 938.

In the USA: a wide variety of parts for the serious and not-so-serious audio constructor is available from Sescom, Inc. Send for a catalogue on hardware, transformers, sips, and many other parts to: Sescom, Inc., 2100 Ward Drive, Henderson, NV 89015-4249 USA. Phone (702) 565-3400; fax (702) 565-4828.

SUPER DISKETTE

3M, in cooperation with Compaq and Matsushita Kotobuki (MKE), have developed a new generation of floppy disks to replace the current 2 MB diskettes. The new diskettes will have a storage capacity of 120 MB. The new drives required will be fully compatible with the current generation of diskettes. It is expected that the new diskettes will be on the market during the course of this year.

In brief

Television and all that

On the 1 June this year, it will be 50 years ago that the first television receiver licences were issued in the UK.

On 6 June, 1954, the Eurovision television link-up was inaugurated.

On 21 June 1937 a male-dominated phenomenon began: the first television broadcast of a sporting event – the Wimbledon tennis championships. Now it seems that television is ruled by sport to the chagrin of the majority of women who feel that there are far too many TV sports broadcasts. Perhaps this is the reason that ...

... more than £ 1,200 million was spent in Britain last year on the sale and rental of video cassettes. Most popular were Pocahontas, Star Trek – the New Generation and The X Files.

It all started with ...

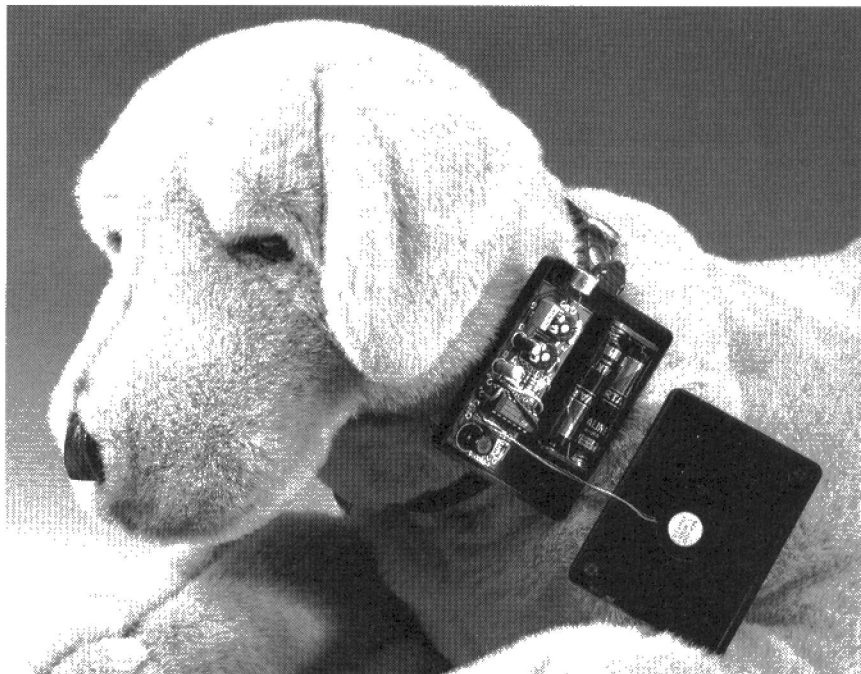
... the first patent for 'communications by electromagnetic waves' which was granted to Marconi on 2 June 100 years ago.

Three developments may make it possible to listen to cds via the Internet in the near future: (1) the us government's relaxation on the use of encryption on the Internet; (2) a cable modem by which a 60-minute cd can be copied in ten minutes; and (3) a chip from Philips that will reduce the cost of recording music from the Internet on to a blank cd.

Dolby Laboratories is working on refining the Dolby Pro Logic encode-decode system for computer applications. The new system, called Dolby Surround Multimedia, will produce surround effects with the use of only two channels. In this way, Dolby reckons that with this system centre front and rear speakers can be dispensed with.



stop that barking!



It is often said that there is no better protection against burglars than a good watchdog. Well, that may be, although we have our doubts. A fact is, however, that many of these 'biological alarm systems' often bark and keep on barking for no apparent reason. Normally, no blame attaches to the dog for this: it just has not been trained properly. The unit described in this article may prove useful in providing correct training.

Design by: K. Walraven

A loudly barking dog may be a deterrent to trespassers and other wrongdoers. Unfortunately, some dogs have never been taught when and why they should bark. A few barks for a good reason are fine, but continual barking soon becomes a nuisance to everyone around, not least the neighbours. And, of course, a dog that always barks is not a good watchdog (by the same reasoning that a burglar alarm which frequently goes off falsely has become useless as an alarm).

The problem often occurs when the dog is left alone in the house. Before a dog is ever left alone, it should be taught a few 'social graces'. This takes time and effort. The dog must be spoken to sternly when it goes on barking: the correct moment is very important. It makes no sense to rebuke a dog in the evening for what it has done wrong during the day: a dog's brain just cannot understand this.

It is appreciated that not everybody can stay at home days on end to speak sternly to a barking dog. It is for these owners that the present circuit may prove a godsend. It is attached to the collar of the dog and contains a small microphone and a beeper. The microphone registers the barking of the dog. If this lasts only a short while, nothing happens. If the barking continues, the threshold of

an acoustic switch is exceeded, whereupon the beeper is actuated and produces an irritating (to the dog) sound. If the dog stops barking, the beeps cease also.

The idea of this is that the dog soon will learn that its barking and the irritating beeps have something to do with one another. The hope is that it will soon learn not to bark unless there is a very good reason for it.

TINY CIRCUIT

Since the 'anti-bark' unit has to be attached to the dog's collar, it is, of course, essential that it is kept small and light. Moreover, since the unit has to be powered by a battery, its current drain must be small. These requirements mean an absolute minimum of components. Figure 1 shows that the design meets these requirements.

It will already be clear that the circuit consists of three distinct parts: the microphone and associated components, including an amplifier stage (IC_{1a}), an acoustic switch formed by a peak detector and a Schmitt trigger (R_3 up to IC_{1c}), and the buzzer and associated components (IC_{1d} - IC_{1f}).

The circuit needs a supply voltage of 3-4.5 V, at which it draws a current of 0.5 mA when the buzzer is operating. In quiescent operation, the cur-

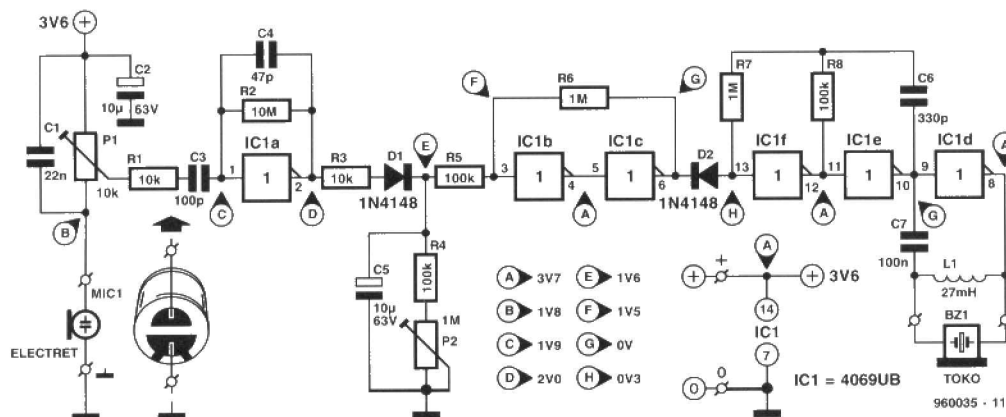


Fig. 1. The circuit may be divided into three: microphone/amplifier (Mic₁-IC_{1a}); acoustic switch (R₃-IC_{1d}); and oscillator/buzzer (D₂-BZ₁). The sensitivity is set with P₁ and the reverberation time with P₂.

rent drain is negligible (which makes an on/off switch superfluous).

OPERATION

When the dog barks, the sound is picked up by the microphone, Mic₁, and converted into an electrical potential. The sensitivity of the microphone is set with P₁.

The signal is applied via R₁-C₃ to inverter IC_{1a}, which functions as an amplifier. Actually, it is a 'selective' amplifier, since C₁, R₁ and C₄ have a low-pass response, whereas C₃ has a high-pass response. In practice, this means that only frequencies in the band 200-1000 Hz (roughly the bark frequency band of an average dog) are amplified.

To create an acoustic switch, the signal amplified in IC_{1a} is applied to peak detector R₃-D₁-C₅-R₄-P₂. The detector is designed such, particularly through the value of R₃, that short-duration barking has no effect on the circuit. If, however, the barking continues, C₅ is charged until Schmitt trigger IC_{1b}-IC_{1c} changes state. Pin 13

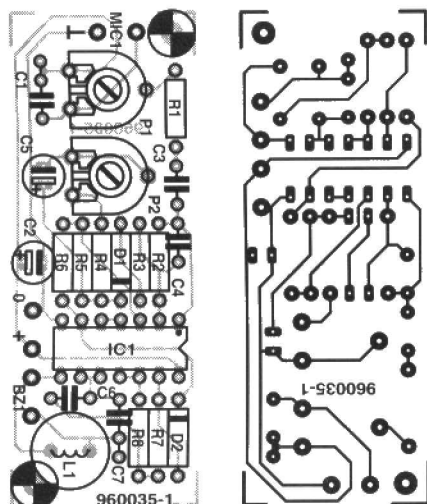
of IC_{1f} is then no longer at earth potential, whereupon oscillator IC_{1e}-IC_{1f} is actuated and the buzzer emits a beep.

The oscillator is a conventional astable multivibrator, IC_{1e}-IC_{1f}, which drives the buzzer via buffer IC_{1d}. Capacitor C₇ prevents IC_{1d} being fed with half the supply voltage, which would increase the current drain.

When the dog stops barking, capacitor C₅ is discharged rapidly via R₄ and P₂, whereupon the Schmitt trigger changes state and the oscillator is disabled. The period during which the buzzer goes on emitting beeps is thus set with P₂.

Since high tones are more irritating to dogs than low ones, the oscillator frequency is set to 7-8 kHz. In the design this created a few problems. As loudspeakers tiny enough to be attached to a dog's collar are not easily found, and in any case their low impedance would require relatively appreciable drive power, a small a.c. buzzer has to be used. Unfortunately, these normally have a resonance frequency of 3-4 kHz and are very inefficient at higher frequencies. The solution proved to be a small choke, L₁, in parallel with the buzzer: this increases the resonance frequency to 7-8 kHz.

Fig. 2. The small dimensions of the PCB ensure a tiny unit.



EASY TO BUILD

The circuit is best built on the printed-circuit board shown in Fig. 2. Populating the board should not take more than an hour. Less experienced constructors: see, however, under testing.

The finished board just does not fit in a standard size matchbox, but it should not be too difficult to find or make a suitable case. This should also take into consideration what batteries will be used.

Because of the tiny current drain, two or three silver-oxide batteries should suffice. If the dog in question is

Parts list

Resistors:

R₁, R₃ = 10 kΩ
R₂ = 10 MΩ
R₄, R₅, R₈ = 100 kΩ
R₆, R₇ = 1 MΩ
P₁ = 10 kΩ preset (but see text)
P₂ = 1 MΩ preset

Capacitors:

C₁ = 22 nF
C₂, C₅ = 10 μF, 63 V, radial
C₃ = 100 pF
C₄ = 47 pF
C₆ = 330 pF
C₇ = 100 nF

Semiconductors:

D₁, D₂ = 1N4148

Integrated circuits:

IC₁ = 4069UB (non-buffered version)

Miscellaneous:

L₁ = choke, 27 mH
BZ₁ = a.c. buzzer (Toko)
Mic₁ = electret microphone insert
PCB order no. 960035 (see p. 60)

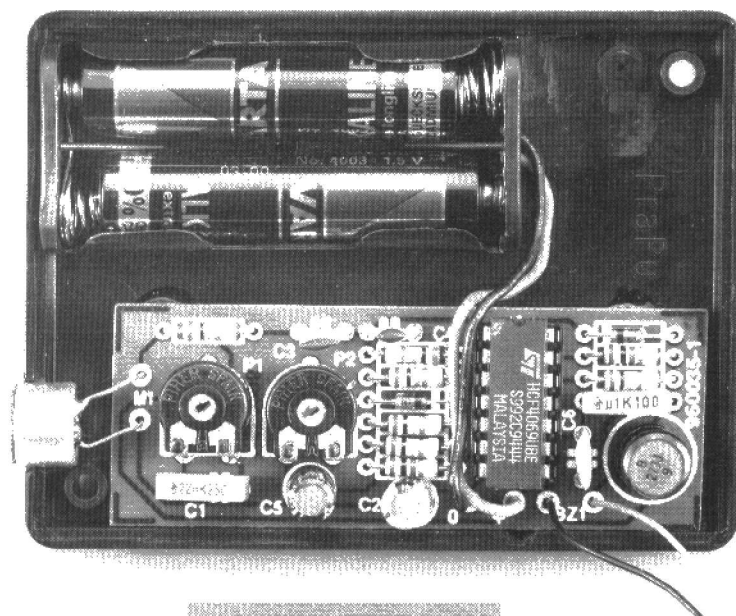


Fig. 3. The supply for the prototype is provided by two HP7 (R6; AA) batteries. If button batteries are used, the unit becomes even smaller.

medium-sized to large, the case does not have to be that small, so that standard HP7 (R6) batteries can be used. Small rechargeable NiCd batteries are also suitable.

The supply voltage should be 3–4.5 V. The buzzer works, of course, best at the higher voltage, but the current drain is then slightly higher. In the prototype, the supply voltage is 3.6 V and the current drain 0.5 mA.

When fitting the microphone, take good care to observe correct polarity (see Fig. 1). In almost all current types, the earth connection (–ve supply rail) is connected to the

casing.

Although the filtering in the input circuits prevents acoustic feedback to a large extent, it is nevertheless advisable to keep the buzzer and microphone as far apart as feasible.

TESTING

Since the design of the circuit is neither complex nor critical, it is more than likely that it functions correctly the first time it is connected to the battery, provided, of course, that it has been built properly.

Less experienced constructors may find it more convenient to build and test the circuit in stages. Start with the oscillator: IC₁, R₇, R₈, C₆, C₇, L₁ and the buzzer. Decoupling capacitor C₂ may also be fitted.

When the battery is connected to the circuit, a well audible tone should emit from the buzzer. If not, temporarily earth pin 13 of IC₁ and, with a multimeter, check the voltages indicated in Fig. 1 around IC_{1d}–IC_{1f}. If very different voltage levels are measured, the likelihood is that the value of one of the components is wrong.

If all is well, remove the battery and the short from pin 13 of IC₁ and add the Schmitt trigger and peak detector: D₂, R₄, R₅, R₆, P₂, and C₅. If then the battery is connected, the buzzer should not sound. If it does, check the relevant voltages indicated in Fig. 1. For an additional check, temporarily link junction R₄–R₅ to the +ve supply line, which should make the buzzer emit a beep. The reverberation time can be set with P₂.

Remove the battery and temporary link from R₄–R₅ to the +ve supply line.

Finally, fit all the remaining com-

Microphones

Microphones are transducers that convert sound energy into electrical energy. The most common types are carbon, crystal, capacitor, moving-coil, ribbon, and electret.

In the moving-coil microphone, a small coil is attached to the centre of the diaphragm. When the diaphragm is made to move, by sound waves, in a steady magnetic flux, an e.m.f. is produced in the coil by electromagnetic induction.

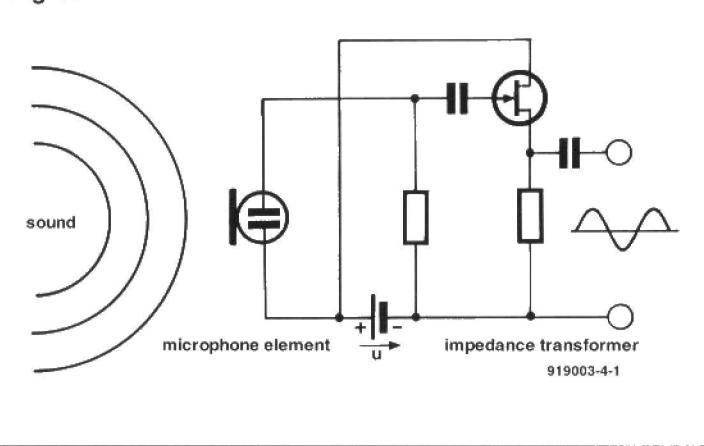
In a capacitor microphone, also called electrostatic microphone, the diaphragm forms one plate of a capacitor. Variations of sound pressure cause movements of the diaphragm and these alter the capacitance. Corresponding changes in potential difference across the capacitor are thus produced. Since the potential changes are very small, an electrostatic microphone is always followed by an impedance transformer/amplifier—see Fig. A.

An electret microphone is also an electrostatic type in which the capacitor is provided with a fixed charge by chemical means. This means that the supply to it can be limited to a small battery for the (integral) amplifier.

Where hi-fi is not important, but sensitivity is, a crystal microphone is often used. This contains a piezoelectric crystal in the form of two plates separated by a small air gap. Sound pressure variations cause displacement of the plates and corresponding e.m.f.s are produced across them. The relationship between sound pressure and produced e.m.f. is fairly linear.

Greater sensitivity is obtained by the use of a separate diaphragm that is mechanically coupled to the centre of the crystal. This construction is more directive, but has a poorer frequency response than the former.

Fig. A



The Internet and other Information Highways

We have to get used to the idea that the Internet is an irreversible phenomenon of present day society. The past few years have seen the consecration of what, with all its treasures to be discovered, is not unlike the cave of Ali Baba or the store room of a medieval alchemist, giving access to all sorts of document, some confidential, some almost secret, and some whose publication is illegal in some countries: the text of the Charter of the Church of Scientologists, the disclosure of the private design of a Eurocrypt card, and others.

Once the cobwebs have been removed, as it were, there are countless treasures to be found, pearls of wisdom, forming a fount of information and knowledge whose data base is a hundred times more powerful than that of the Library at Alexandria at its height. In other words, a source of information that is second to none on earth.

Even so, do not be mistaken in thinking that this is all: there are already a number of formidable competitors, such as Compuserve, Microsoft Network System (MNS), and America on Line (AOL).

It will be essential to actually employ the, sometimes unsuspected, potential of the Internet, enabling it to be turned into the primary source of services of many kinds, from automatic adjustment of the pc's real-time clock (yes, it is possible already), to on-line employment exchanges, and promote it so that the net does not collapse like a house of cards when there are not tens of millions of people seeking access like today, but several hundreds of millions. There remains plenty to do for those who have the difficult task to steer the Internet to a full blossoming tree of knowledge, whose fruits we can all gather and eat.

It is, however, essential for the survival of the Internet, and others, to guarantee that its freedom of access extends to all information. It must not become a question of accepting that whatever country, however powerful it may be, whether it be the Federal Republic of Germany, the United States of America, or France, can propose and obtain a blocking, even a partial one, of access to any source of information.

On close examination, it is industrial conglomerates that provide line telephone services who have the ways and means of making the Internet, and others, a commonplace. This applies particularly to AT&T in the USA, which proposes a free, permanent access to the services of the Internet via its international telephone network, and the many European telephone administrations, private or public.

The greatest priority today is the assurance of free access to the available mass of information, potential and actual, not to the maximum number of people, but to those who can, in one way or another, take advantage, if possible intellectual and cultural, rather than commercial or financial, from the networks.

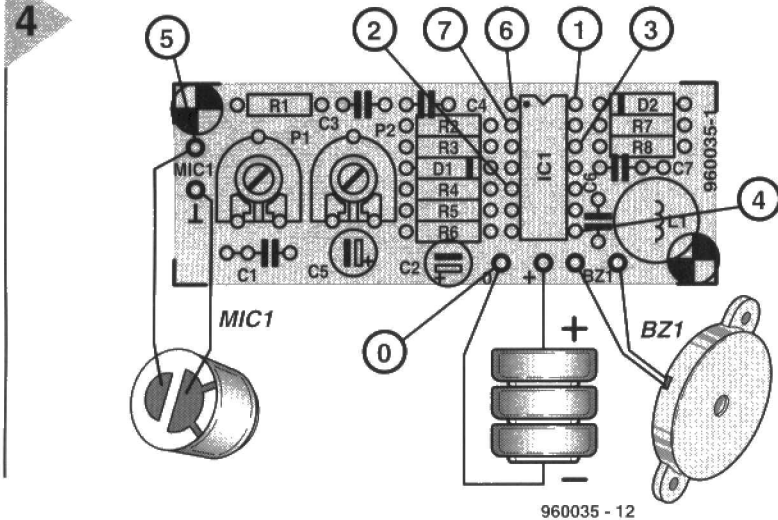


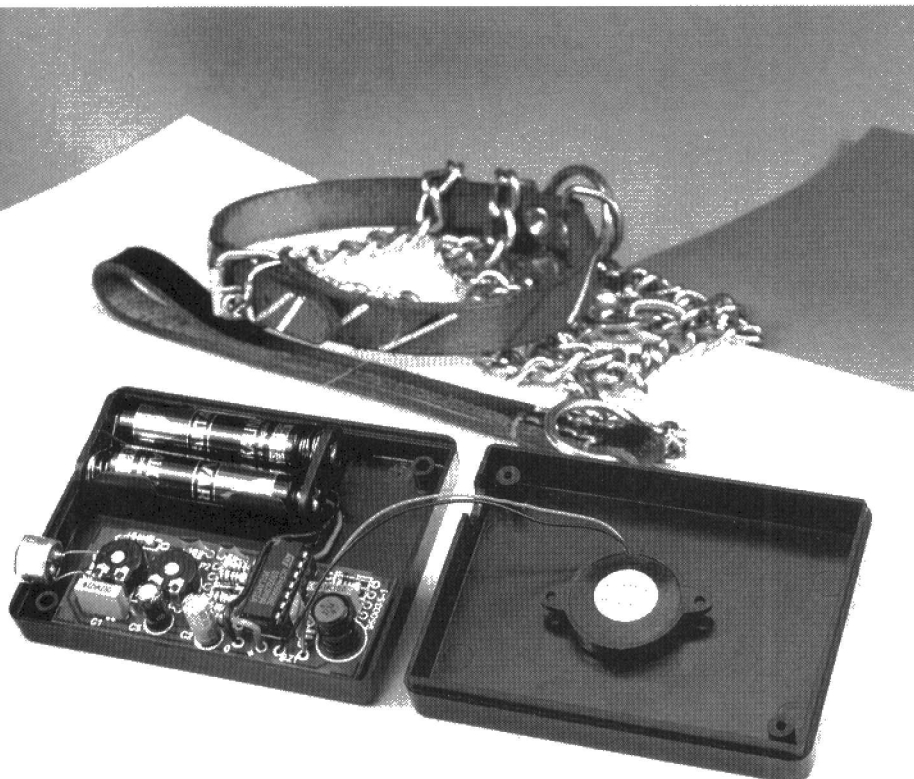
Fig. 4. On the pcb is indicated not only where to connect the various components, but also where the test points are. (1, 2, 3, 4 = U_{BI} ; 5, 6, 7 = $U_B/2 \pm 0.3$ V; 0 = ground = -ve supply line)

ponents, including the microphone. Test the unit by setting P_1 to maximum sensitivity and blowing into the microphone: the buzzer should emit a sound.

The best setting of P_1 has to be found empirically: it depends to some extent on the tolerances of the microphone. If the sensitivity of the electret type is not sufficient for individual requirements, a crystal type should be tried. This should give enough voltage to make

the circuit react to even the most subdued bark. If this is done, it is advisable, however, to increase the value of P_1 to 100 k Ω and reduce that of C_1 to 2.2 nF.

[960035]





23cm ATV preamplifier

Amateur television (ATV) is among the most popular, technically advanced and exciting sub-activities available to the licenced radio amateur with an interest in centimetre-wave technology. These days, the main ATV activities are in the 23cm band (1252-1285 MHz) where privately operated transmitters and relay stations may be received, often in full colour and complete with sound. The fun is not restricted to licensed amateurs, though! These transmissions can be picked up by anyone having a suitable antenna, an old satellite TV receiver and a preamplifier like the one Johannes, DL4EBJ, describes in this article.

Based on GaAs-FET, MSA and microstrip technology, the design couples low noise with high gain. Although aimed at the advanced radio amateur, the preamplifier is relatively easy to build and adjust.

Design by J. K ring, DL4EBJ

low noise, high gain



MAIN SPECIFICATIONS

Gain:	>35 dB (3-stage)
Noise figure:	<1 dB (MGF1302)
Filter:	microstrip, 3-element interdigital
Frequency range:	1,250-1,300 MHz
Peak frequency:	1,285 MHz
Current consumption:	<60 mA
Simple adjustment	
High repeatability (SMD)	
Remote powered by Sat-TV receiver	

This article presents a challenge to gigahertz newcomers by describing a low-noise preamplifier, which is one of the key elements in a receive-only station for 23cm amateur television. The other elements are a suitable antenna (loop-yagi), a satellite TV tuner and a TV set or video monitor. Most of these will be available to the beginning radio amateur. If not, then local club members may be able to help out! Actually, the preamplifier and the loop yagi antenna are often the only elements which are home-made. Let's look at each of the elements in some detail to see which requirements they should meet.

THE SATELLITE TV RECEIVER

Most satellite TV receivers have a frequency range of 950 MHz to 1,750 MHz, which means that they can be tuned across the entire 23cm band (1,240 to 1,298 MHz). The good news is that almost any satellite receiver, irres-

pective of its age can be used to receive 23cm ATV. A good example is the now obsolete Amstrad SRX200 receiver, which can be picked up for a tenner or less at rallies and car boot sales. A number of features of the satellite receiver are, however, advantageous if you want to 'go ATV':

- ★ continuously tuneable sound (5 MHz to 8 MHz). Most ATV-ers use a sound subcarrier at 6.0 MHz or 5.5 MHz. The former frequency appears to be preferred for new design.
- ★ sound bandwidth reduction ('narrow') mode, this may help to drag a weak sound subcarrier out of the noise.
- ★ selectable IF bandwidth. Only high-end (expensive) receivers allow the video detection bandwidth to be reduced from 27 MHz to 18 MHz. As with sound, being able to switch to 'narrow' bandwidth may mean the difference between a picture lost in noise and one which shows at least

- ★ a frequency readout is helpful, because a weak ATV station may be a needle in a haystack.
- ★ adjustable video gain: most ATV stations use a quite low FM video deviation as compared to satellite TV stations. Obviously, some extra gain is then useful to boost the contrast and brightness.
- ★ an S meter is useful and practical while you aim the antenna, or peak the preamplifier, for best reception.

THE ANTENNA

An antenna designed for the SSB sub-band (1,296-1,298 MHz) achieves its high gain and directivity by virtue of the small bandwidth only. A considerably lower gain has to be taken into account if you use such an antenna in the ATV range of the band, 1,250 to 1,285 MHz. If you are after good results across the entire 23cm band, be sure to purchase any of the wide-band antennas already on the market.

THE ANTENNA PREAMPLIFIER

These tuners are relatively insensitive. In particular, the FM PLL demodulators they contain require much higher input levels than an antenna could ever supply without a preamplifier. Even preamplifiers as used for SSB (narrow band) do not quite make it in this respect.

band ATV, and meets all of the above mentioned requirements for use in combination with almost any satellite TV tuner. Not convinced? Then look at the specs box.

The circuit diagram of the preamplifier is shown in **Figure 1**. The antenna signal is d.c. decoupled by C9. The source of the MGF1302 GaAs FET is matched to the antenna impedance ($50\ \Omega$) by two small inductors, L1 and L2. The matching used here does not have the traditional trimmer capacitor at the input. The advantages of omitting the trimmer are a higher Q factor of the input circuit, lower input losses, a lower noise figure and, last but not least, a much simpler adjustment.

fed to a tuned three-element inductively coupled interdigital microstrip filter which defines the pass-band of the preamplifier, and serves to reject strong out-of-band signals (UHF TV transmitters and cellular radio repeaters). The inductors in the filter are small copper tracks (strips) on the printed circuit board. The input signal for the second active element, IC1, is taken from a tap on the last printed inductor, L9. This is done to ensure correct matching (approx. $50\ \Omega$) to the input of the MSA0685 (Hewlett Packard, formerly Avantek). The circuit around the two $50\text{-}\Omega$ 'drop-in RF amplifiers', IC1 and IC2, should be familiar to most amateurs, as these devices have been used in many recently published designs. The noise figure of the MSA0685 is about 3.2 dB, but that is really insignificant in this application.

The total gain of the preamplifier is

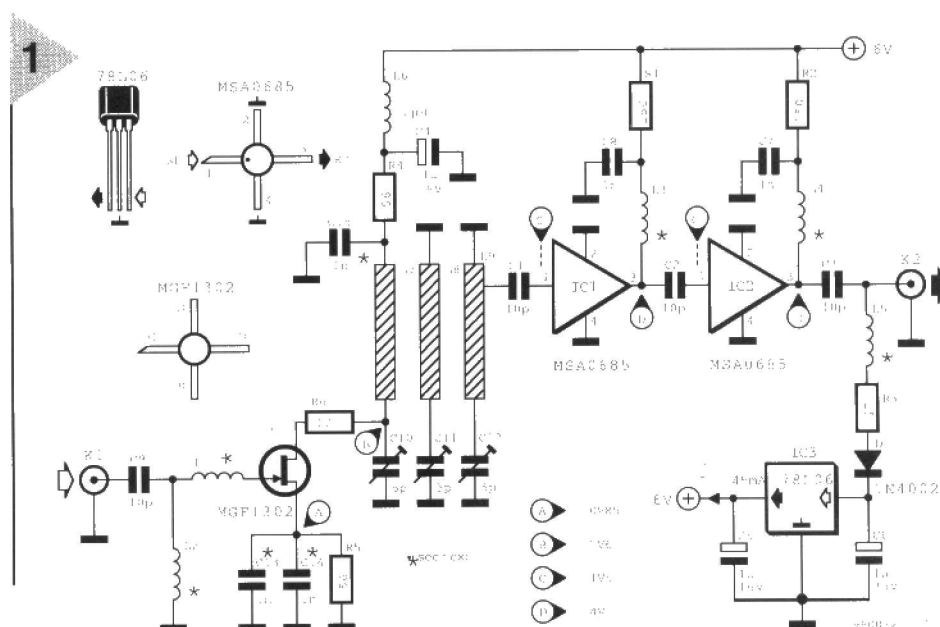


Figure 1. Circuit diagram of the 23cm ATV preamplifier. A microstrip interdigital filter is used to select the ATV section of the 23cm amateur radio band. The input has an ultra low noise GaAs FET from Mitsubishi.

The GaAs FET provides a gain of about 14 dB here. Its output signal is

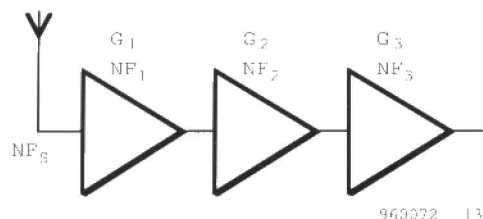
To keep stray capacitance and inductance as low as possible, most passive components in the RF path are

surface-mount devices (SMDs).

The input supply voltage is obtained from the satellite TV receiver via the downlead coax cable. Most receivers supply either 14 V or 18 V, depending on the LNC polarity selection (which is of no consequence here). A voltage regulator type 78L06 is used to step down the LNC voltage to a regulated 6-V rail for the GaAs FET and the MSA's. The overall current consumption will be smaller than 60 mA. Diode D1 provides a polarity reversal

Please keep the noise down...

The three-stage preamplifier described here is no exception to the rule that the first stage determines the overall noise figure, provided the following stages supply enough gain.



Assuming that each stage has a gain, G_n , and an associated noise figure, NF_n , the system (or overall) noise figure, NF_s , may be written as

$$NF_s = NF_1 + \frac{NF_2 - 1}{G_1} + \frac{NF_3 - 1}{G_1 G_2}$$

This proves that the noise figures of the second and third stage of the amplifier, NF_2 and NF_3 , hardly contribute to the system noise figure because these stages provide high gain. In practice, a system noise figure of about 1 dB may be achieved, which comes very close to the value specified by the manufacturer of the GaAs FET used in the preamplifier described here. Such a low value was unheard of less than ten years ago. However, any mismatch between the antenna and the input stage seriously degrades the noise figure, as do losses ahead of the

protection. Choke L5 prevents the RF output being short-circuited by the supply. Each of the MSA stages draws about 15 mA, while the MGF1302 operates at a current of about 12 mA. These settings may be verified with the aid of the test voltages indicated in the circuit diagram.

CONSTRUCTION HINTS

The printed circuit board designed for this project is a bit of a small master-

piece, and a great help to prevent all of the notorious problems said to exist in relation with gigahertz construction. The artwork is shown in Figure 2. You are looking at a double-sided copper-clad epoxy board, which is available ready-made through our Readers Services. As shown by the component overlay, nearly all parts are fitted at the top side of the board. Only the three Sky trimmer capacitors are mounted at the other side of the board. That is

done to prevent unwanted inductive coupling which could cause feedback and oscillation. It also helps to prevent the 'cover-on/cover-off' effect which some of you may know from adjusting centimetre-wave amplifiers. The printed circuit board fits in a tin-plate case with a standard size of 37×74×30 mm.

Now take a look at the construction drawing in Figure 3. Carefully drill the two 5.2-mm holes for the disc capacitors at the source terminals of the

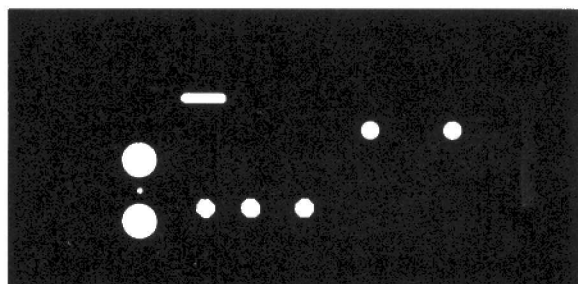
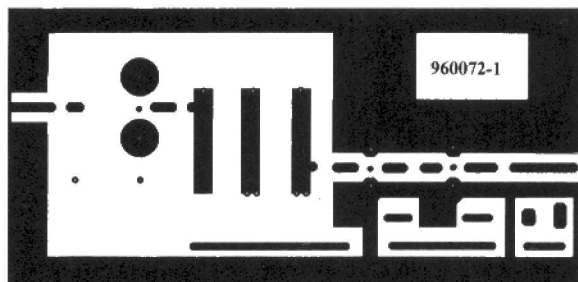
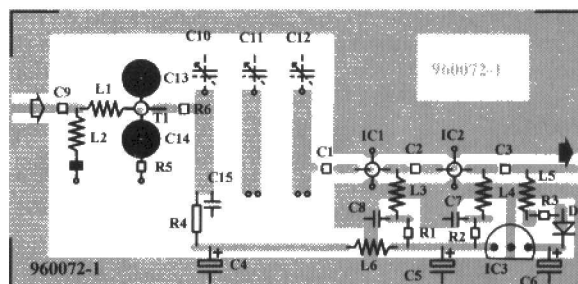


Figure 2. Printed circuit board artwork. Only the three miniature trimmers are fitted at the reverse side of the board.

GaAs FET. At the reverse side of the board, these capacitors are connected to ground with the aid of small pieces of copper foil. The MGF1302 and the MSA's require 2-mm dia. holes to be drilled. Next, drill and fraise the slot for the coffin-style leadless ceramic capacitor, C15. The length of the slot should match the width of the microstrip inductor, L7. C15 should not fall through the slot, instead, its wider part should rest on the top surface of the board.

Prepare the tin-plate case so that it can receive the circuit board. Drill holes in the short sides for the RF input and output sockets (use BNC or N, whichever is available), using the PCB as an orientation aid. The centre pins of the sockets are later soldered directly on to the copper tracks on the board. If necessary remove the PTFE cover around the centre pin, and reduce the pin to a length of about 3 mm from the inside of the flange. Secure the sockets at the outside of the case, then align the board so that the centre pins rest on the respective copper strips. Next, secure the board in the case by soldering all around the edges, at both sides.

3

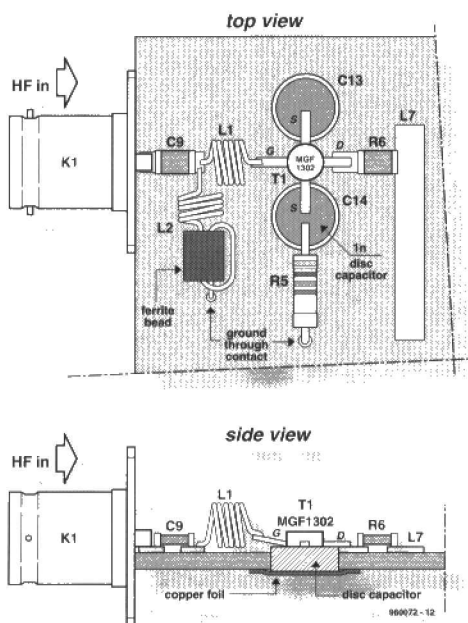


Figure 3. Construction drawing showing how to mount the components that make up the low-noise input stage.

COMPONENTS LIST

Resistors:

R1, R2 = 150Ω SMD
R3 = 47Ω SMD
R4, R5 = 56Ω
R6 = 10Ω SMD

Capacitors:

C1, C2, C3, C9 = 10pF SMD
C4, C5 = 1μF 16V tantalum
C6 = 1μF 35V tantalum
C7, C8 = 1nF SMD
C10, C11, C12 = 5pF miniature PTFE trimmer (Sky)
C13, C14 = 1nF disc ceramic (see Fig. 3)
C15 = 1nF coffin style leadless ceramic

Inductors:

L1 = 5 turns 0.2mm (32SWG) e.c.w., inside dia. 1mm
L2 = 4 turns 0.2mm (32SWG) e.c.w., inside dia. 1mm + 1 turn through 3mm ferrite bead
L3, L4 = 5 turns 0.3mm (30SWG) e.c.w., inside dia. 2mm
L5 = 4 turns 0.3mm e.c.w. (30SWG) through 3mm ferrite bead
L6 = 10μH choke
L7, L8, L9 = microstrip (see text)

Semiconductors:

D1 = 1N4148
T1 = MGF1302 (Mitsubishi)
IC1, IC2 = MSA0685 (Hewlett Packard), or MAR6 (Mini Circuit Laboratories)
IC3 = 78L06

Miscellaneous:

K1, K2 = BNC or N socket, flange type
Tin plate case 37x74x30 mm
Printed circuit board, order code 960072-1 (see Readers Services page)

possible wires. Wires that go to ground are soldered at both sides of the board to provide through-contacts. When all parts (except the MGF1302) are fitted on the board, use your multimeter to track down short-circuits, dry joints and unwanted ground connections.

The most delicate component to fit is the GaAs FET. Mark the gate terminal on the body, then carefully shorten all terminals. Solder the two source terminals flush on the disc capacitors. The drain is soldered to the copper pad, and the gate terminal is lifted up a little so that it can be soldered directly to inductor L1 as indicated by the side view in Figure 3.

ADJUSTMENT

Connect the antenna cable to the RF input, then the downlead coax cable to the RF output. In some cases, the preamplifier is then 'on' already, because some satellite TV receivers supply the LNC voltage even if they are switched to standby.

Now take your time to verify the test voltages indicated in the circuit diagram. You should have no problems finding these points on the circuit board.

The fun begins once you have found a kind soul who can put a strong local 23-cm ATV signal on the air. If you do not live near an ATV repeater, use the ATV calling/talkback calling channel, 144.750 MHz, to find a fellow amateur with the required equipment.

Tune the satellite

TV receiver to the transmit frequency of the station you wish to receive, for example, 1285 MHz. The adjustment is limited to the three Sky trimmers. As a guide, the stator plates should be turned 'in' at about 10% only of the available travel. This corresponds to a setting of about 1 pF. A plastic trimmer tool is recommended for the adjustment. The cover should be fitted on the case during the adjustment.

Those of you who want the preamplifier to cover the entire ATV section of the 23cm band may have to increase the bandwidth of the interdigital filter. This is achieved by fitting a 1-pF capacitor between the 'hot' end of L7 and L8 (i.e. directly on the Sky trimmers), and another between L8 and L9, also at the 'hot' ends.

Provided you power the preamplifier with an external voltage, it is possible to connect a 23-cm 'phone' (SSB/FM) transceiver, and peak it for the highest S meter reading on a weak repeater or beacon signal (better leave the transmitter in the transceiver off for the moment, HI).

Assuming that the preamplifier is properly adjusted, it is ready for mounting as close as possible to the antenna. You will then be amazed at the not inconsiderable distances that can be covered with excellent picture quality.

SIGN -

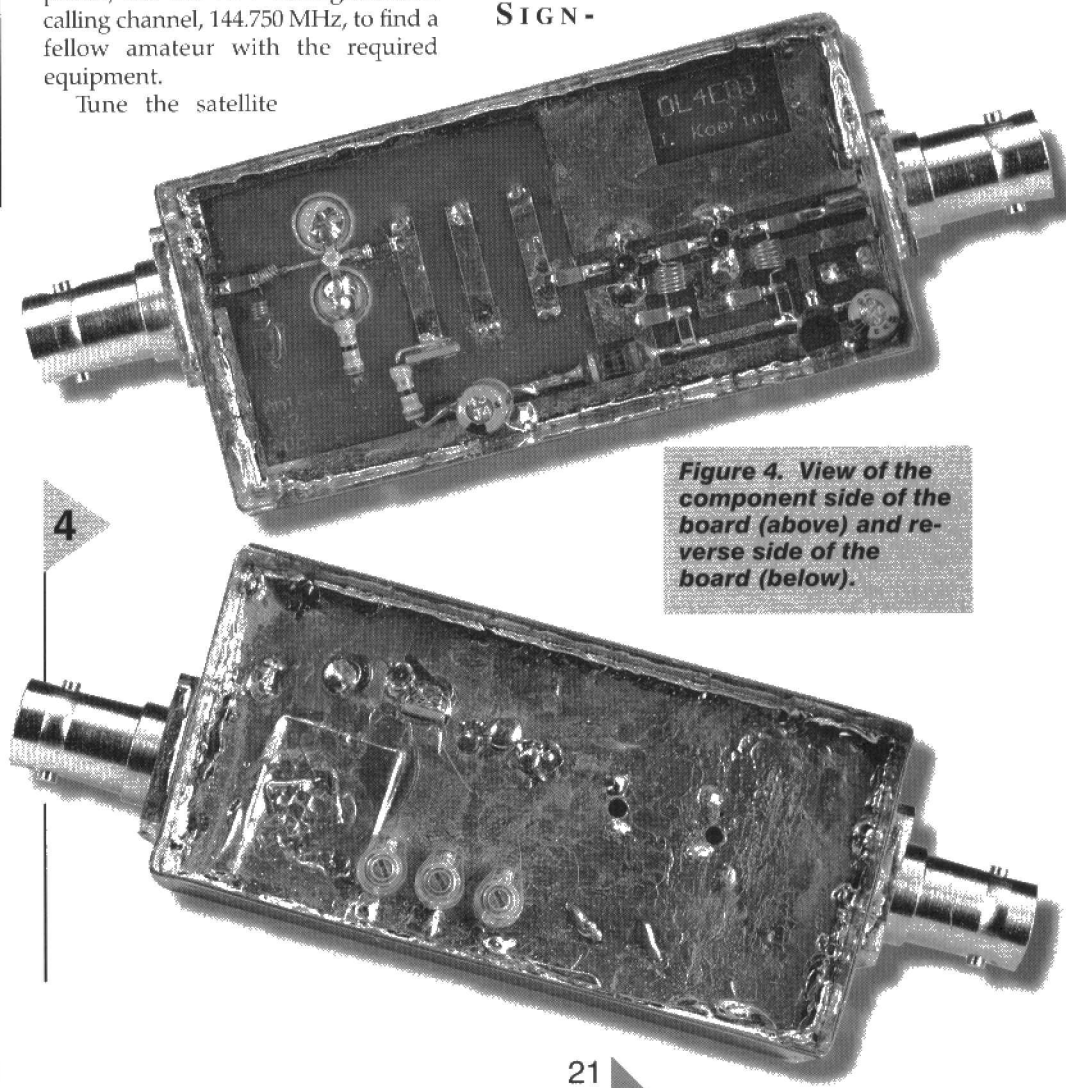


Figure 4. View of the component side of the board (above) and reverse side of the board (below).

Populate the board, starting with the passive parts. The ICs and the extremely delicate GaAs FET are fitted last, observing precautions against static electricity. The pinning of these devices is shown in the circuit diagram.

The partly three-dimensional construction around the GaAs FET should be copied from the drawing in Figure 3. Start by fitting the small pieces of copper foil at the reverse side of the board. Next, pre-tin the inside surface. Insert the disc capacitors into their respective holes, and make sure they fit snugly. Then apply heat to the copper foil until the disc capacitor starts to float in the solder tin, and sinks into place. The same for the other disc capacitor. At the component side, solder the tinned area of the coffin capacitor, C15, to the 'cold' end of L7. This is quite delicate work, so be sure to avoid a short-circuit to ground. The other side of the capacitor is soldered to ground, at the reverse side of the board.

The capacitors, resistors and so on should be mounted with the shortest

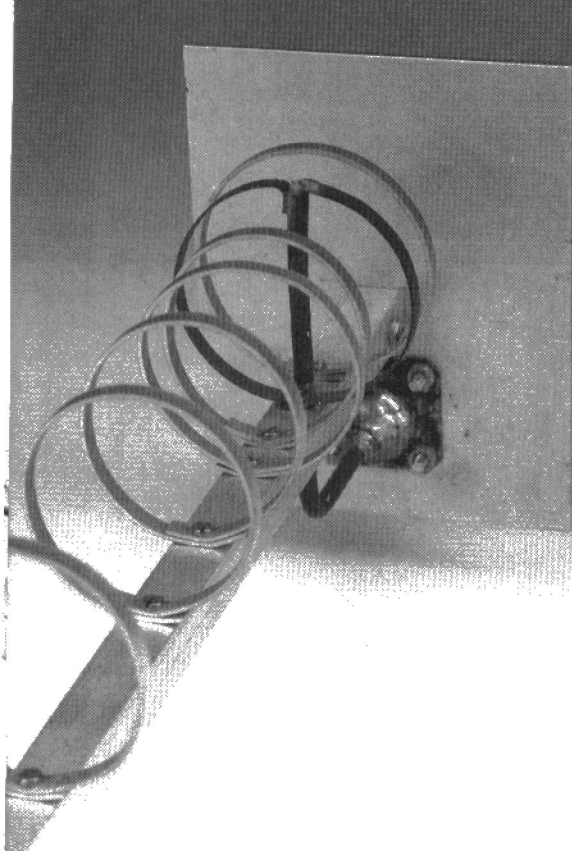


Figure 5. The best known antenna for 23-cm ATV use is the loop yagi. Pictured here is a home-made loop-yagi scaled for 13 cm (courtesy Rob, PE1CHY).

operation of Reiner, DB9JC and Hans, PE1IZR, are gratefully acknowledged.

Lots of success with the construction, and happy ATV viewing! (960172)

Editorial notes:

1. This article appeared in shortened form in *Electron*, issue September 1995. We thank the editors of *Electron* for their permission to run this article in *Elektor Electronics*.

2. Readers in the UK with an interest in ATV should contact the British Amateur Television Society (BATC), c/o Ian Pawson G8IQU, 14 Lilac Avenue, Leicester LE1 1FN.

For information on ATV repeater stations in the UK, write to Graham Hankins G8EMX, 11 Cottesbrook Road, Acocks Green, Birmingham B27 6LE.

The BATC may be found on the Internet at <http://ourworld.compuserve.com/homepages/ipawson>

3. A 23cm ATV transmitter was described in the February 1994 issue of *Elektor Electronics*.

ING OFF...

If you are the fortunate owner of a satellite TV receiver which remains in the shack and can be used exclusively for ATV, it is definitely worth while to increase the video gain in the receiver. Use your oscilloscope to measure the video signal level (approx. 1 V_{pp}), and adjust the AGC in the tuner for the best signal-to-noise ratio of the received picture.

If you omit the entire pre-stage between C9 and L9, interrupt the connection to L6, and omit everything to the left of it, you have a multi-purpose 25-dB wideband amplifier which may be used to compensate cable losses between the receiver and the output of an LNC.

Finally, the contributions and co-



ATV

PI6ANH



JO21XW

ARNHEM

PI6ANH



IN 1252MHz
IN 10400GHz
OUT 2387MHz
AUDIO 6MHz

PI6ANH



N 75°
W ↔ 0 ↔ E
230° S FREE

PI6ANH

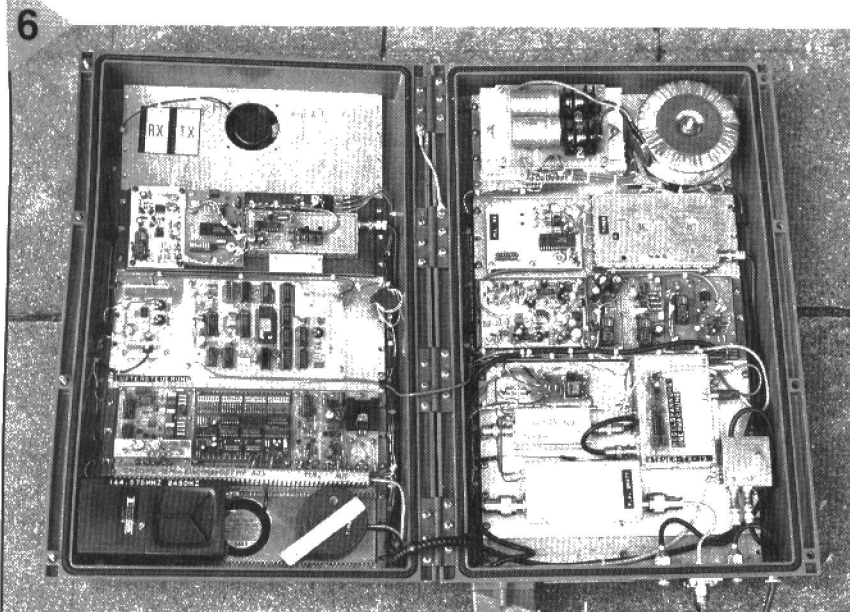
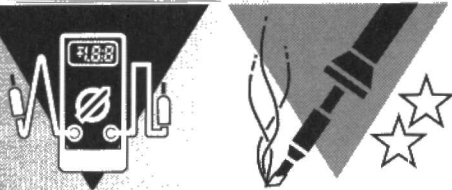


Figure 6. What do you mean home construction is on the decline? Pictured here are the electronics of a 23cm-in/13cm-out cross-band ATV repeater station, PI6ANH, which was recently taken into use. The QTH of this station is JO21XW, ERP is about 50 W, and the antenna height is 40 m a.s.l. A wonderful example of high-end equipment built and operated by radio amateurs, this repeater is one of dozens located at elevated sites all over Europe. PI6ANH even has its dedicated Internet site at <http://www.regio.rhein-ruhr.de/hamradio/atv>.

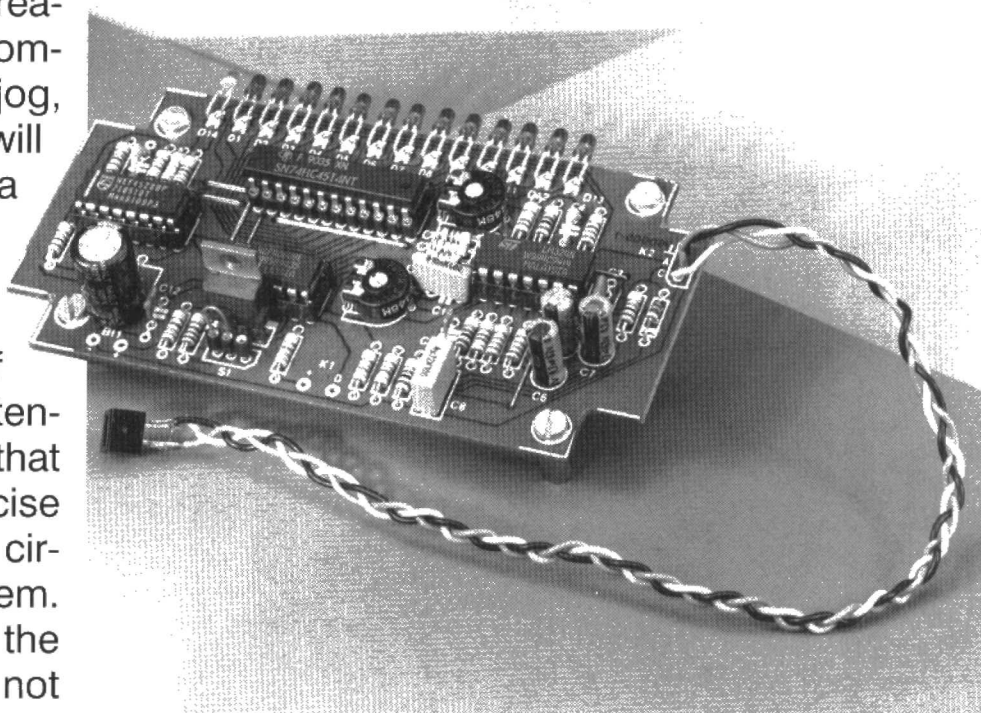


pulsimeter

If, for whatever reasons—health, competition—you jog, cycle, row, you will know that after a certain amount of time your pulse beats faster. This is, of course, the intention, because in that way you exercise your heart and circulatory system. This is fine, but the heart beat must not become too high, because that is dangerous. How far you can let it rise depends on various factors, such as age and physical condition. The present meter enables you to check that you do not exceed your maximum pulse rate.

In sporting circles, there is a rule of fist to determine your maximum pulse rate: depending on your physical condition, it should not go over 180–200 less your age in years. Thus, if you are in good condition and 40 years old, your maximum pulse rate should not exceed 140–160 bpm (beats per minute).

Design by: F. Hueber



This is not a problem as long as you know what your pulse rate is. It is, of course, simple to take your pulse or count your heart beats, but to do so you have to interrupt your sporting activities for a minute or so. There are various pulsimeters (also called pulsometer) on the market, most of which have additional functions, such as a VHF radio alarm clock, telephone cost counter, data bank with 100 words in 19 European languages, and so. Because of these extras, such meters are unnecessarily expensive. Moreover, some of these instruments appear to be fragile and not at all suitable for use during sporting activities. The present meter is straightforward: it measures only one thing: your heart beat and shows this by means of a bar of LEDs.

A particular problem with this kind of meter is the kind of sensor—and there are several. One could consist of stick-on or suction electrodes as used for taking an ECG—ElectroCardioGram. However, although they are ideal for measuring the heart beats, for everyday use they are a little too cumbersome (they have to be secured to the skin of the chest).

A second method is the acoustic determination of the heart beat, which can be carried out with a sphygmomanometer (blood pressure meter) and a stethoscope or microphone in

the inflatable bag around the arm. The heart beat is then heard. Of course, this method is not very practical during sporting activities either.

Less well known, but very usable, is the optical measurement. The translucence of human tissue changes with each heart beat: when the heart pumps blood through the arteries, the tissue becomes less translucent. (Shine a torch at one of your fingertips and look at the tip from the opposite side from the torch). This phenomenon is not, or hardly, noticeable with the naked eye, but can easily be made so by electronic means. The light source in the present meter is an infra-red (IR) LED, while the detector consists of an infra-red-sensitive phototransistor. These two devices may form a hybrid light barrier or a reflection light barrier (when they are in parallel with one another). Whatever, they are connected to a more or less translucent part of the body, such as a fingertip or an ear lobe.

ANALOGUE AND DIGITAL

As shown in Figure 1, the circuit of the pulsimeter is fairly straightforward. It consists of an analogue section, in which an LM324 amplifies and processes the signal from the sensor, and a digital section, which deals with

the counting and the display.

The sensor output is applied to input socket K₂ (top left). Low-pass filter R₁₄-C₈ prevents high frequencies being processed: it only passes relatively slow signals. The value of bipolar coupling capacitors C₆-C₇ accords with the low frequencies: 50 bpm is equivalent to 0.78 Hz and 200 bpm to 3.33 Hz. This composite capacitor, formed by two polarized types, prevents any direct voltages, which vary appreciably according to whether or not the sensor is connected or whether it detects spurious light, from reaching IC_{1a}.

The op amp, IC_{1a}, functions as a linear amplifier (×200). Network R₁₁-C₅ forms a further low-pass filter (cut-off frequency is 15 Hz) to suppress any residual interference.

The output of IC_{1a} is a reasonably usable signal that looks a little like a pulsating sine wave with superimposed noise. This signal is converted into a clean rectangular waveform by comparator IC_{1d}. The threshold of this stage is set with P₂ to a level within the amplitude of the sine wave. The setting of the preset is not critical, since all that is left at the inverting input of analogue monostable multivibrator IC_{1c} are positive and negative needle pulses.

In quiescent operation, the output of the monostable is low and C₃ is not charged. With incoming signal, the output of the monostable goes high at each trailing edge of the comparator input. It remains so until C₃ has been charged via R₆. Then, in about 20 ms, the potential at the non-inverting input of the op amp falls below the level at the inverting input (the needle pulse has long passed), whereupon the monostable changes state again (output low). The 20 ms long pulse is clearly visible by the lighting of D₁₄ (green LED).

Potential divider R₃-R₄ halves the 9 V supply voltage: the consequent 4.5 V supply is buffered by IC_{1b} and used as reference for the monostable. Because of this arrangement, the battery voltage can drop as low as 6 V.

In contrast to that to the analogue

section, the supply line to the digital section is held stable at 4.5 V. Although the CMOS-ICS can work from 3–15 V supplies, the frequency of the oscillator, determined by R₁-C₁-P₁, depends on the level of the supply line. Therefore, the supply is stabilized at 4.2–4.5 V by presettable regulator IC₅. This type of regulator is much more economical than, for instance, a 7805, and can work with battery voltages below 6 V.

The pulsimeter draws a current of some 15 mA, which allows the use of a 9 V (PP3) battery. It is, however, advisable to use a rechargeable battery, which can be charged via a 12 V mains adaptor via R₂₃ when S₁ is in the position shown in Figure 1. If the battery is charged by a standard battery charger (with the pulsimeter off), R₂₃ must be replaced by a wire bridge, so that the battery is connected directly

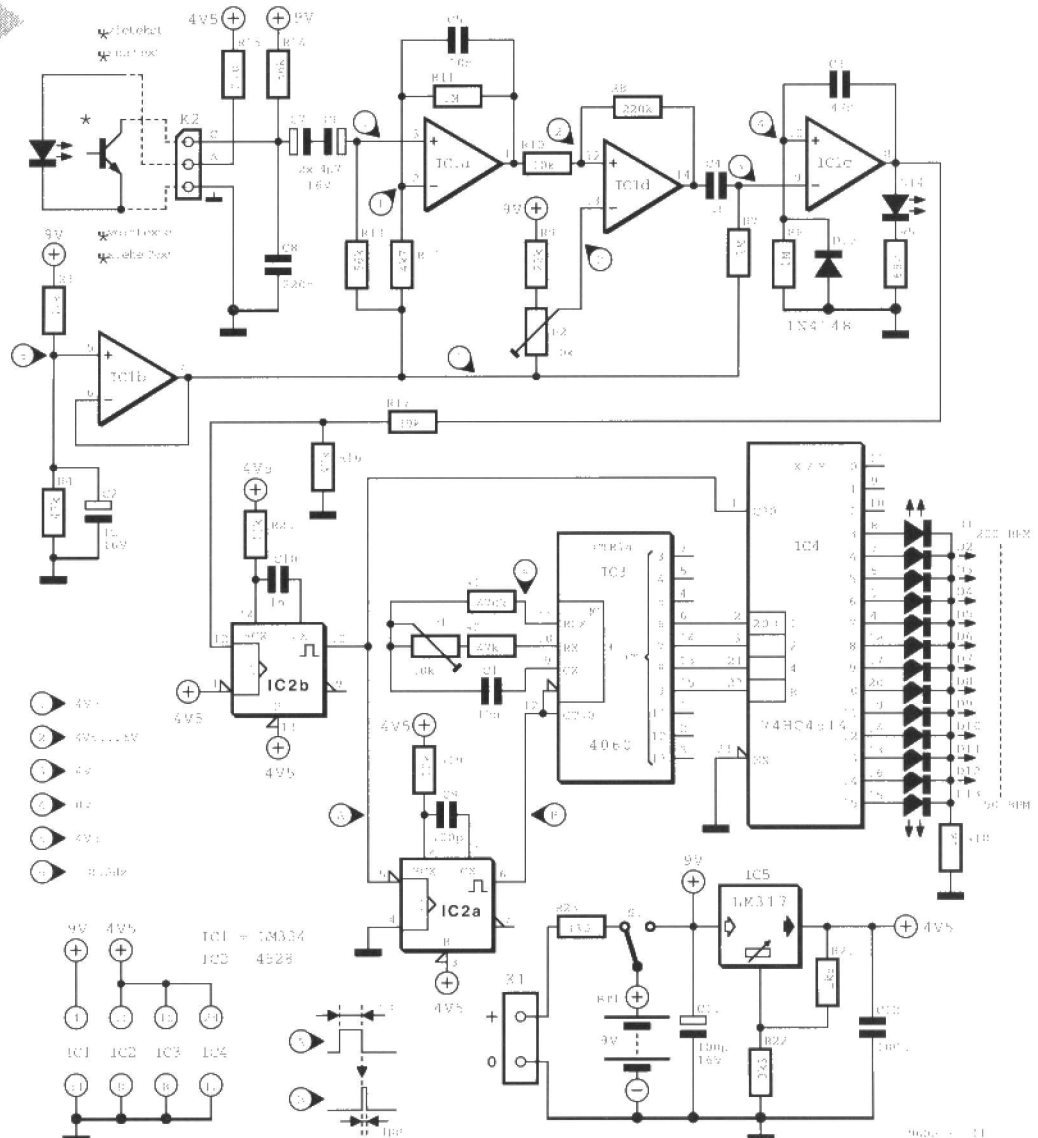
Figure 1. The circuit of the pulsimeter consists of an analogue section (measurement and processing) and a digital section (evaluation and display). The scale of the LEDs is non-linear.

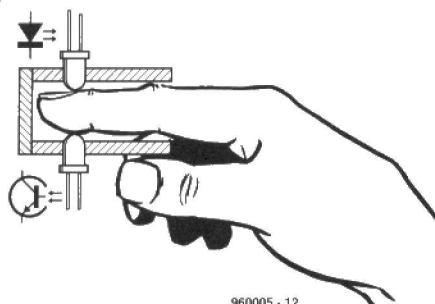
to the terminals of K₁.

The voltage level between the output of the monostable and IC_{2b} must be lowered from 6–9 V to 3–5 V and this is effected by voltage divider R₁₆-R₁₇.

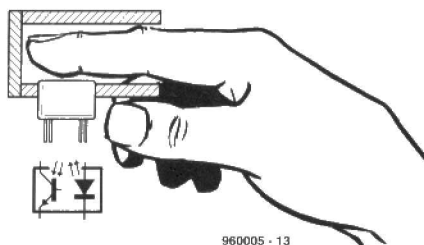
Each pulse emanating from the analogue section triggers monostable IC_{2b}, whose output is used as a strobe pulse that is applied to 4-to-16 decoder IC₄. The trailing edge of the strobe pulse triggers a second monostable, IC_{2a}. The output of this stage, 1 μs pulses, is used to reset counter IC₃ to zero.

The oscillator in IC₃ clocks the counter at a rate of about 850 Hz. The longer the time interval between two heart beats, the higher the counter state will be. The oscillator frequency is arranged so that at the lowest heart beat the range used by the counter (CT6–9) just does not overflow, but counts exponentially up to 1111, dur-

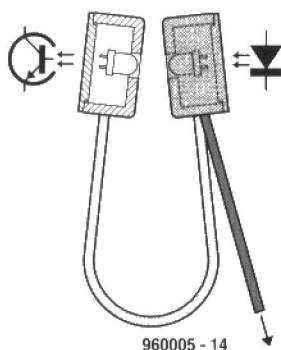




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960005 - 14

ing which D_{13} is switched on by IC_4 . Decoder IC_4 has four input latches that become transparent when the strobe pulse arrives at pin 1. The following decoder converts the 4-bit binary number at the respective output terminals.

THE SENSOR

The sensor for the pulsometer is not commercially available and must, therefore, be made by you. Since it does not have to be a work of art, the simplest and cheapest sensor is made from a clothes-peg. Drill a 5 mm dia. hole in each of the short legs, about 5 mm from the top. Insert the IR diode into one hole and the IR photo transistor into the other. Connect the two devices to K_2 with two-core screened cable. This sensor can be

Figure 3. Although the printed-circuit board is not densely populated, the construction remains compact.

Scale correlations of the LED chain

bpm	seconds	Hz	LED
50	1.28	0.78	D13
53	1.125	0.89	D12
57	1.050	0.95	D11
61	0.975	1.03	D10
66	0.9	1.11	D9
73	0.825	1.21	D8
80	0.750	1.33	D7
89	0.675	1.48	D6
100	0.6	1.67	D5
124	0.525	1.91	D4
133	0.450	2.22	D3
160	0.375	2.67	D2
200	0.3	3.33	D1

clipped on to a finger or an ear lobe.

Some more elegant and less 'pressing' designs are shown in Figure 2. Those in *a* and *b* use a 40–50 mm long tube (electrical conduit will do nicely) with a diameter that just, but comfortably, fits over a finger. One end of the tube must be sealed off light-tight. Drill two 5 mm holes as shown more or less where the fingernail will be (where best results will be obtained). Insert the IR diode into one hole and the IR phototransistor into the other, so

that they fit snugly over the fingernail. Fix them in that position with superglue. Connect them to K_2 with 2-core screened cable as shown in Figure 1.

If instead of the hybrid light barrier a reflection type is used, make the construction as shown in Figure 2b. In this case, a rectangular hole must be cut and filed in the tube into which the device just fits. The electrical connection is as with the ear-

lier construction.

If the sensor is to be fitted on to the ear lobe, the best design is really the clothes peg or something like it as shown in Figure 2c. With this design, it is important to make sure that the pressure on the ear lobe is as light as feasible, without the risk that it will fall off during the sporting activity.

Whatever the design, it is essential that the sensor is absolutely light-tight.

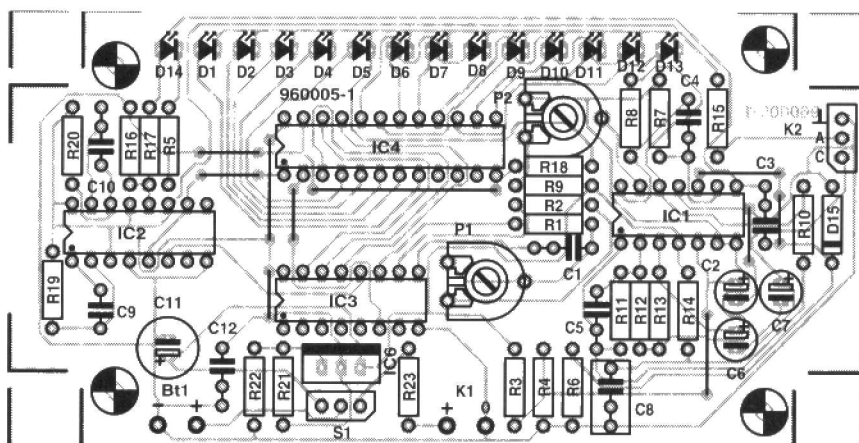
CONSTRUCTION

The pulsometer is best built on the printed-circuit board shown in Figure 3 and then fitted in a small enclosure measuring 125×65×40 mm ($5 \times 2\frac{1}{2} \times 1\frac{1}{2}$ in).

Drill the holes for the LEDs in accordance with their positions on the PCB: this will ensure that afterwards the lid can be easily removed from the enclosure if need be.

Fit the socket for the sensor cable on one side of the enclosure, and the charging socket and switch on the other side.

In many cases, it is advisable to fit a securing clip, such as a belt strap, at



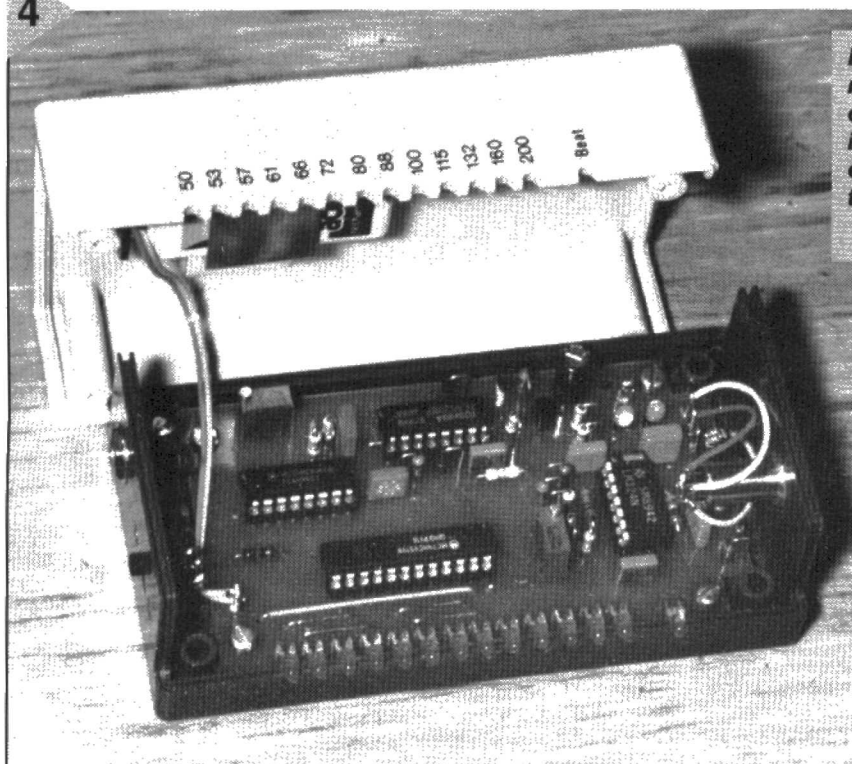


Figure 4. The battery may be fixed with a clip (well insulated!) inside the cover of the enclosure without touching the board.

the outside of the bottom of the enclosure.

When all soldering work has been completed, the board may be fitted into the enclosure, whereupon IC₃ and IC₄ (but not IC₁ and IC₂) can be inserted into their respective sockets.

As a first check, connect a 1 k Ω resistor across C₁₂, and supply the circuit with 9 V from a workshop power unit. Check that the voltage at the output of regulator IC₅ is 4.2–4.3 V. This voltage should be retained when the output of the power unit is reduced to below 6 V. Remove the 1 k Ω resistor.

The LED chain is tested by short-circuiting pins 4 and 6, and pins 10 and 11, of the socket for IC₂. The LEDs should then light in sequence as in running lights. Remove the short-circuits.

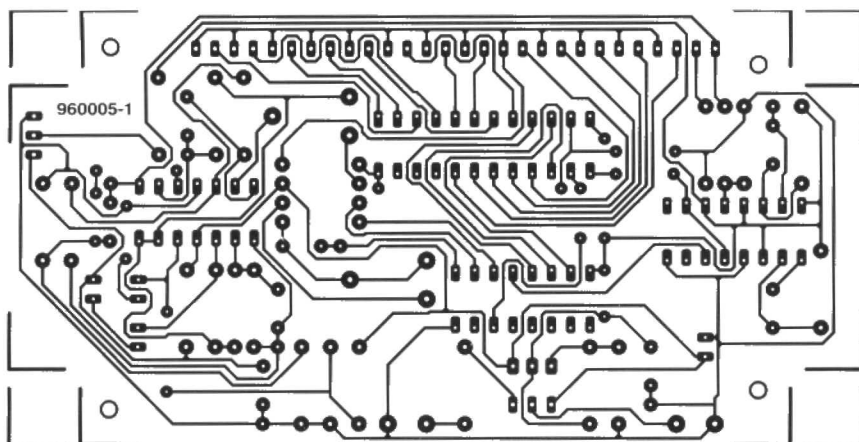
Remove the sensor, insert IC₁ and IC₂ into their respective sockets, and connect a frequency meter to pin 11 of IC₄. Adjust P₁ until the meter reads

847–849 Hz. Remove the meter.

With a DVM (digital voltmeter) measure the voltage at pin 1 of IC₁, which should be about half the supply voltage, and adjust P₂ until the meter reading has risen by about 200 mV.

Reconnect the sensor, connect it to a finger or ear lobe, and switch on the pulsometer. After a few seconds (to allow C₆–C₇ to get charged), the meter should work satisfactorily. It may be that the sensitivity of it should be corrected with P₂. If the wiper of this preset is at or near to half the supply voltage, the circuit is at its most sensitive. It is, however, better to adjust P₂ so that the heart beat is detected clearly, shown by D₁₄ pulsating in an identical rhythm, without small sensor movements upsetting the circuit. The LED chain should show between 60 bpm and 80 bpm when the pulse is normal. So don't get too excited about the success of your work!

[960005]



PARTS LIST

Resistors:

- R₁ = 470 k Ω
- R₂–R₄, R₁₆ = 47 k Ω
- R₅ = 680 Ω
- R₆, R₇, R₁₁ = 1 M Ω
- R₈ = 220 k Ω
- R₉ = 22 k Ω
- R₁₀, R₁₉, R₂₀ = 10 k Ω
- R₁₂ = 4.7 k Ω
- R₁₃, R₁₄ = 56 k Ω
- R₁₅ = 270 Ω
- R₁₇ = 39 k Ω
- R₁₈ = 1 k Ω
- R₂₁ = 1.5 k Ω
- R₂₂ = 3.3 k Ω
- R₂₃ = 330 Ω
- P₁, P₂ = 10 k Ω preset

Capacitors:

- C₁, C₅ = 10 nF
- C₂ = 1 μ F, 16 V, vertical
- C₃ = 47 nF
- C₄, C₁₀ = 1 nF
- C₆, C₇ = 4.7 μ F, 16 V, vertical
- C₈ = 220 nF
- C₉ = 100 pF
- C₁₁ = 100 μ F, 16 V, vertical
- C₁₂ = 100 nF

Semiconductors:

- D₁–D₁₃ = LED, high-efficiency, 3 mm, red
- D₁₄ = LED, high-efficiency, 3 mm, green
- D₁₅ = 1N4148

Integrated circuits:

- IC₁ = LM324
- IC₂ = 4528
- IC₃ = 4060
- IC₄ = 74HC4514
- IC₅ = CNY70 (Telefunken) or discrete IR diode and IR phototransistor (see text)
- IC₆ = LM317

Miscellaneous:

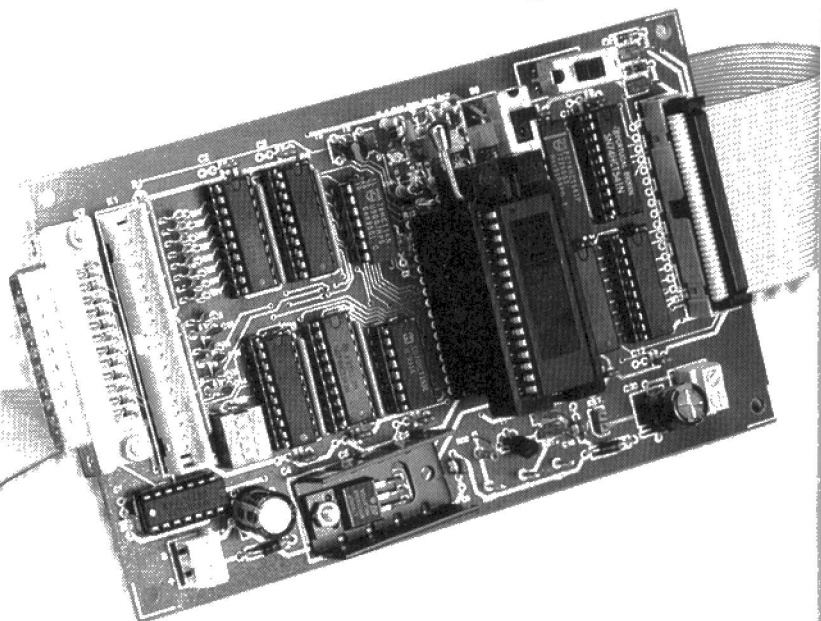
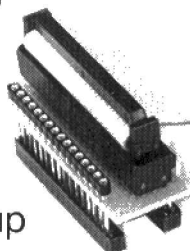
- K₁ = 2 off soldering pin
- K₂ = 3-pin terminal strip for board mounting
- S₁ = single-pole change-over switch
- BT₁ = 9 V dry or rechargeable battery (see text)
- Enclosure, 120×65×40 mm, Bopla E430 or OKW N120



Flash EPROM programmer/emulator

*a multi-purpose programmer/emulator,
not just for microcontroller circuit development*

The most comfortable as well as expensive way of developing microcontroller circuits is to emulate the relevant controller with the aid of an in-circuit emulator. Among the less costly options are a monitor program and an EPROM emulator. Unfortunately, a monitor program uses up some of the controller's resources. This serious disadvantage is avoided by using an EPROM emulator which behaves basically like a dual-ported RAM: one side has an interface like that of an EPROM, while the other provides the logic that pumps a data-stream into the RAM.



past, and built successfully by thousands of users around the globe, we have to admit that the most recent design dates back to 1992, and is no longer up to date in view of its maximum data capacity of 'only' 64 Kbyte.

When companies like AMD first introduced 'Flash' EPROMs featuring a single 5-V programming voltage and a lifetime of about 100,000 programming cycles, a totally new perspective became available for the design of a new type of EPROM emulator. The present design not only acts as an EPROM emulator with a huge storage capacity, it also doubles as a Flash EPROM programmer, saving you the expense that would have gone into purchasing a dedicated programmer.

Having finished with the EPROM emulator during the design phase, the Flash EPROM containing the latest, tested code may be removed from the emulator and plugged into the application circuit. Because prices of Flash EPROMs are not much higher than those of regular EPROMs, the additional luxury described above comes free of charge, in other words, it does not even add to the cost of building the present design.

WHAT IS A FLASH EPROM?

Apart from the fact that Flash EPROMs have a *write* input, their actual behaviour in normal use does not differ much from regular EPROMs. The difference is only apparent from the way the data are loaded into the EPROM, and erased again. While ordinary EPROMs require a well-defined programming voltage to be present for a certain period of time, and the component may be erased again by exposing the chip to a certain dose of UV light, these two processes are internally controlled and carried out in a Flash EPROM. To that effect, the Flash EPROM receives an accurately defined command sequence (erase, program) which includes special precautions (set up by the manufacturer) to ensure that an erase action can not happen just like that.

The relevant command is transferred to the Flash EPROM via a series of write operations, as illustrated by Table 1. The two first commands, *Read/Reset*, reset the Flash EPROM, and prepare it for normal read operations. The *Autoselect* command allows the manufacturer code and the device type

EPROM emulators are by no means novelties to regular readers of *Elektor Electronics*. Although a number of these projects were presented in the

Design by C. F. Urban

Table 1. Flash-EPROM commands

Command	Cycles	First Bus Write Cycle		Second Bus Write Cycle		Third Bus Write Cycle		Fourth Bus Write Cycle		Fifth Bus Write Cycle		Sixth Bus Write Cycle	
		Addr.	Data	Addr.	Data	Addr.	Data	Addr.	Data	Addr.	Data	Addr.	Data
Read/Reset	1	XXX	F0										
Read/Reset	4	5555	AA	2AAA	55	5555	F0	RA	RD				
Autoselect	4	5555	AA	2AAA	55	5555	90						
Byte Program	4	5555	AA	2AAA	55	5555	A0	PA	PD				
Chip Erase	6	5555	AA	2AAA	55	5555	80	5555	AA	2AAA	55	5555	10
Sector Erase	6	5555	AA	2AAA	55	5555	80	5555	AA	2AAA	55	SA	30

Address bits A15-A18 are X (don't care) for all address commands except Program Address (PA) and Sector Address (SA)

All data and addresses are in hexadecimal notation

RA = Address of memory location to be read.

PA = Address of memory location to be programmed (on negative WE edge).

SA = Address of sector to be erased.

RD = Contents of memory location RA

PD = Contents of memory location PA (on negative WE edge)

to be read. The command *Byte* loads the program into the EPROM, while *Chip Erase* actuates the erasing process which should normally take less than a minute to complete. From a point of view of logic, the Flash EPROM is divided into sectors which may be read individually with the aid of the *Sector Erase* command.

A Flash EPROM offers yet another protection mechanism to protect it against unintentional write or read actions on a sector-by-sector basis. A sector protected in this way can not be read or (over)written with just a 5-V voltage. This is an important fact to keep in mind with used devices. The protection may only be undone with the aid of a special programmer.

During the program or erase process, the status of the Flash EPROM may be read from the same location as the programmed or erased byte, after a command with normal 'read' access. With sector erasing, the status information may be read from any address within the sector.

During the programming sequence, the highest-order bit, DQ7, in the byte being read holds the negated value of the one being programmed, while bit DQ5 holds a 0. After success-

ful programming, this inversion is undone, bits 5 and 7 then holding the planned values.

Because all memory locations appear to be programmed with the value FF_H during an erase sequence, bit 7 is then invariably 0 during the process. When an internally fixed time limit is exceeded during either of these two processes ('timing error'), bit 5 toggles to 1, and bit 7 retains its inverted state. The function of bit 6 is implemented because of compatibility requirements. Bit 3 is used when several sectors are to be erased simultaneously. Neither of these features are, however, used in the EPROM emulator described here. Detailed information which you may require for your own software designs may be found in the databooks published by the manufacturer, AMD (address at the end of this article).

ADDRESSES AND DATA

The block diagram of the emulator/programmer is shown in Figure 1. Behind the parallel interface with the PC are a couple of address registers, a data register and a multiplexer which reduces the number of data lines to the PC to just two. The Flash EPROM is at

the centre of the circuit.

When the Flash EPROM has to be programmed only, all other circuit blocks are inactive. In emulator mode, the Flash EPROM is read by the application circuit, via a buffer. The application circuit is connected to the block marked 'emulator probe'.

The EPROM Emulator we published in 1992 uses the Centronics standard to communicate with the PC. That was easy, really, because a static RAM was used that required only one write operation per byte. With the present circuit, a pure Centronics-based communication would not be possible without highly complex hardware and software. Thus, although the programmer/emulator makes use of the PC's parallel printer port, the protocol used for the actual communication is definitely not the Centronics standard.

In addition to eight datalines, the parallel port offers four control lines in the direction of the EPROM emulator, and five status lines which may be used individually for simple read or write commands.

Three of the latter lines are used to supply clock signals to an equal number of registers IC2, IC3 and IC4, which latch a total of 19 address lines (A0 through A18), one line for OE, and four lines for the selection of a CE signal (CE1 through CE4). The fourth control line generates the WE signal. Because the Flash EPROM only copies the byte on the databus on the edge of the WE signal, the registers and the Flash EPROM share the eight datalines available on the parallel interface. During read operations (OE = low), bus driver IC5 disconnects the datalines from the Flash EPROM. This is achieved by inverting the OE signal (in IC1c) and applying it to the enable signal for IC5.

Only five lines are available to read

Table 2. Status reports during programming and erasure operations

	Status	DQ7	DQ6	DQ5	DQ3
Working	Auto-Programming	DQ7	toggles	0	0
	Program/Erase in Auto Erase	0	toggles	0	1
Time limit exceeded	Auto-Programming	DQ7	toggles	1	1
	Program/Erase in Auto Erase	0	toggles	1	1

a byte, so that it is necessary for two 4-to-1 multiplexers to reduce the eight datalines to just two. Consequently, the PC has to access these lines four times for every complete byte. Because the registers only copy the data on the datalines on the low-to-high edge of the drive signals CLK1, CLK2 and CLK3, they may be used for controlling the multiplexers. As regards the control software, however, one should take into account that on each state change of the control lines only that specific byte is available which belongs with a register whose CLK line changes from low to high. The arrangement of the data lines on the multiplexer is such that bit 7 and bit 5 are automatically selected after the last write operation of a command sequence. The remaining signal distribution across the multiplexers just enables a simple software solution to be applied for reading a complete byte.

The switching between emulator and programmer mode is realized likewise. When one of the three control lines CLK1, CLK2 or CLK3 is logic high, then the *wired-OR* configuration of three open-collector inverters (IC1d, IC1e, IC1f) ensures that the *Load* signal is actuated (i.e., goes low). This causes the outputs of registers IC2, IC3 and IC4, as well as bus driver IC5, to be enabled, so that the address and datalines of the host circuit are separated from those of the Flash EPROM.

At the same time, a *Reset* signal is being prepared which allows the pin marked *RST* (on FET T1) to go active low, and the pin marked *RST+* to go active high. When *Active-High-Reset* is applied, it is possible to apply either a +5-V level (jumper fitted), or 'steal' a corresponding level from the application circuit (via the *RST+* pin). The latter option is particularly interesting when a member of the 80C51 microcontroller family is used because it allows the usual reset capacitor to be shunted. Resistor R22 then limits the current to an acceptable level. It does not, however, act as a continuous current limiter, because T1 may be damaged if too much current flows.

This mode selection operating via the three CLK lines on the parallel interface enables the PC software to reset the host (application) circuit without having to reload the emulator. The same function is carried out by the RE-SETAPP utility program, which may be found on the distribution diskette which is available for this project through our Readers Services (order code 956017-1).

R-C networks R4-C13, R5-C14, R6-C15 and R13-C16 suppress internal

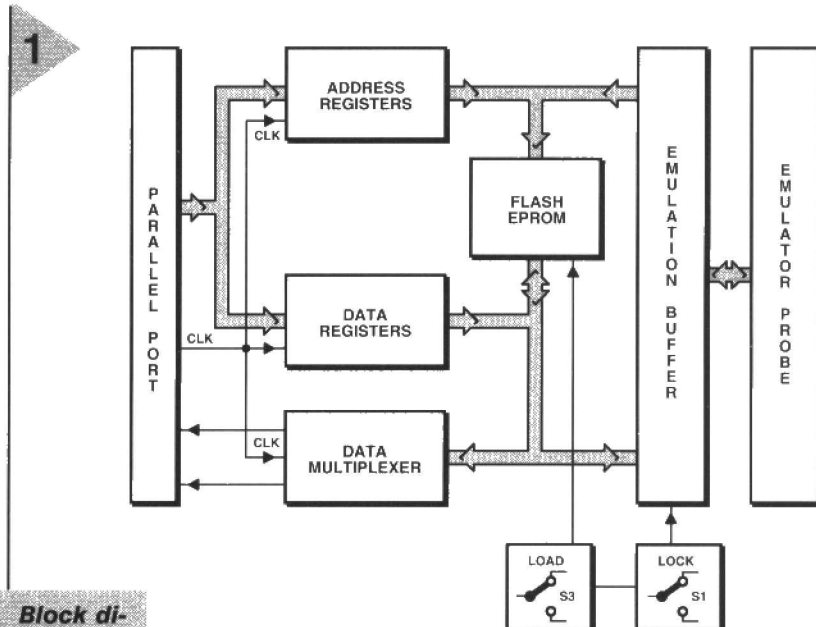


Figure 1. Block diagram of the Flash EPROM programmer/emulator, and the setting on switch block S4 for different EPROM capacities.

S4	8kb	16kb	32kb	64kb	128kb	256kb	512kb
A16	OFF	OFF	OFF	OFF	ON	ON	ON
A18	OFF	OFF	OFF	OFF	OFF	OFF	ON
A17	OFF	OFF	OFF	OFF	OFF	ON	ON
A14	OFF	OFF	ON	ON	ON	ON	ON
A13	OFF	ON	ON	ON	ON	ON	ON
A15	OFF	OFF	OFF	ON	ON	ON	ON

960077 - 12

and external spurious pulses on the control lines. The delays caused by these networks should be compensated by the software. The delay is, therefore, measured by the program: if the multiplexer is disabled (CE inactive), a logic one is programmed on the C14 and C16 lines. Next, the multiplexers are enabled (CE active), and data lines D0 and D2 are selected. When these two lines supply 1's, the time may be measured that has elapsed between outputting the pulse edge on the CLK3 line and the instant the level changes of D0 and D2.

The measured (and slightly lengthened) period strictly applies to the delay which is valid for the CLK3 line. To make sure that this delay is sufficient for the other control lines too, the R-C time of R6-C15 is about twice that of the other R-C networks. The delay also helps to avoid problems which may arise from the use of computers with different speeds.

PROGRAMMING FLASH EPROMS

When the emulator is used as a programmer, S3 allows the Flash EPROM to be removed without any risk, and without having to disconnect the programmer from the PC or the power supply. The switch simply disables the 5 V supply for the Flash EPROM. It also causes the *WE* signal to be pulled to 0 V (via T2 and inverter IC1f) and effectively disconnects the Load signal so that the register and bus driver outputs are disabled. Diode D3 and the inverter

then block the signals of the address line drivers in the application circuit. All lines are pulled to 0 V by means of resistor arrays (R7, R8, R9 and R10). The Flash EPROM may be removed from the socket when LED D1 goes out.

Switch S1 allows the emulator to be used autonomously. When the emulator is disconnected from the PC, pull-up resistors R1 and R2 pull all lines logic high. That would normally cause the circuit to switch to programmer mode, but the *Load* signal is effectively blocked by switch S1 and a pull-up resistor in array R2. So, the circuit remains in emulator mode.

POWER SUPPLY

The emulator may be powered via the EPROM socket of the host circuit via D8 and D9. It is, however, better to power it from its own regulator, IC8, which is protected by D6 and D7, or from an external 5-V voltage source connected to K8. Jumpers 28 and 32 determine whether the supply voltage arrives via pin 28 or 32 of the socket or EPROM. They must, however, be fitted only when the supply voltage arriving via D8 or D9 is not reliable.

The address and data lines of the EPROMs are compatible. **Be sure, however, to avoid a situation in which the host circuit receives no supply voltage, because IC12 then drives the datalines in the host circuit.** The unstabilized input voltage for the regulator may be obtained from an inexpensive 12-V mains adaptor which is connected to socket K3 on the board.

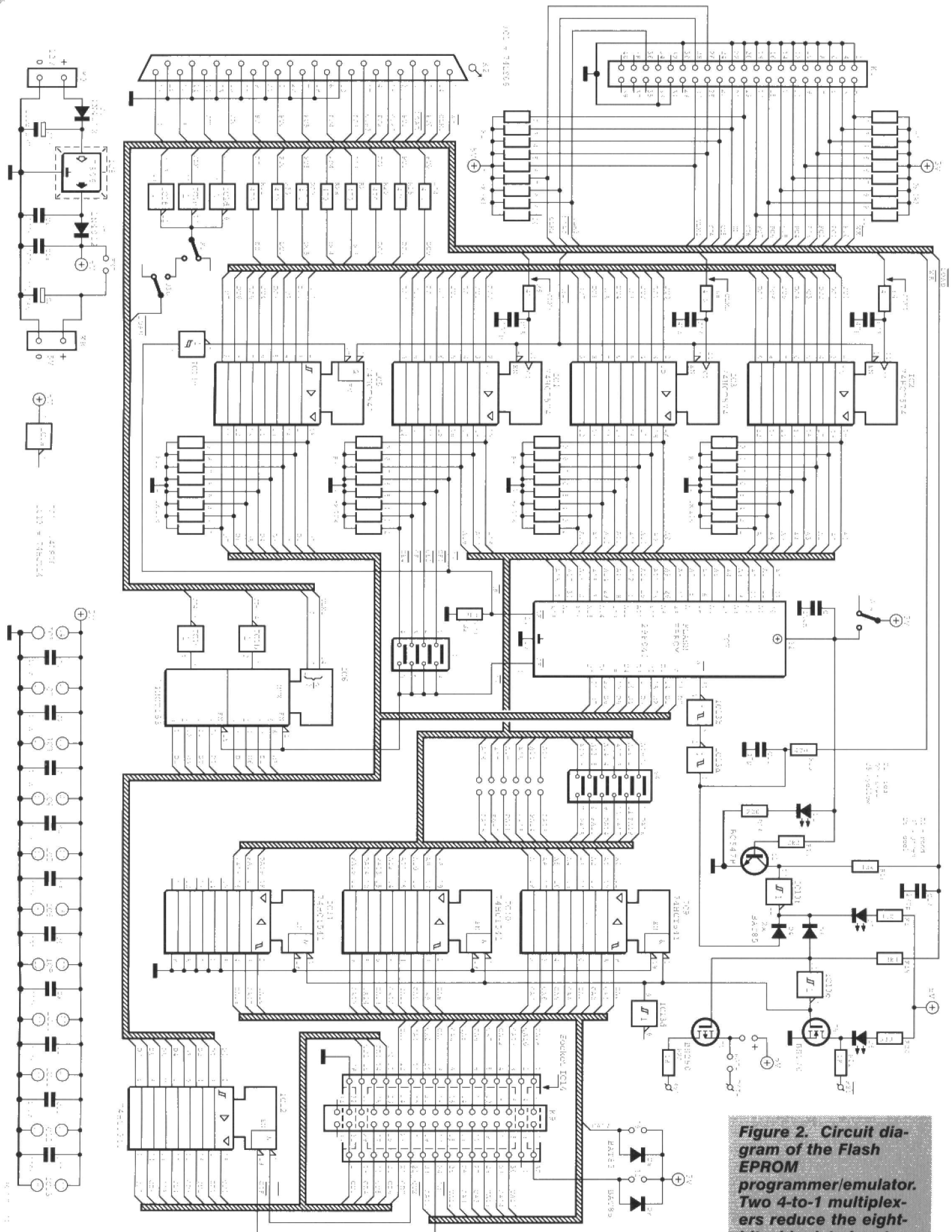
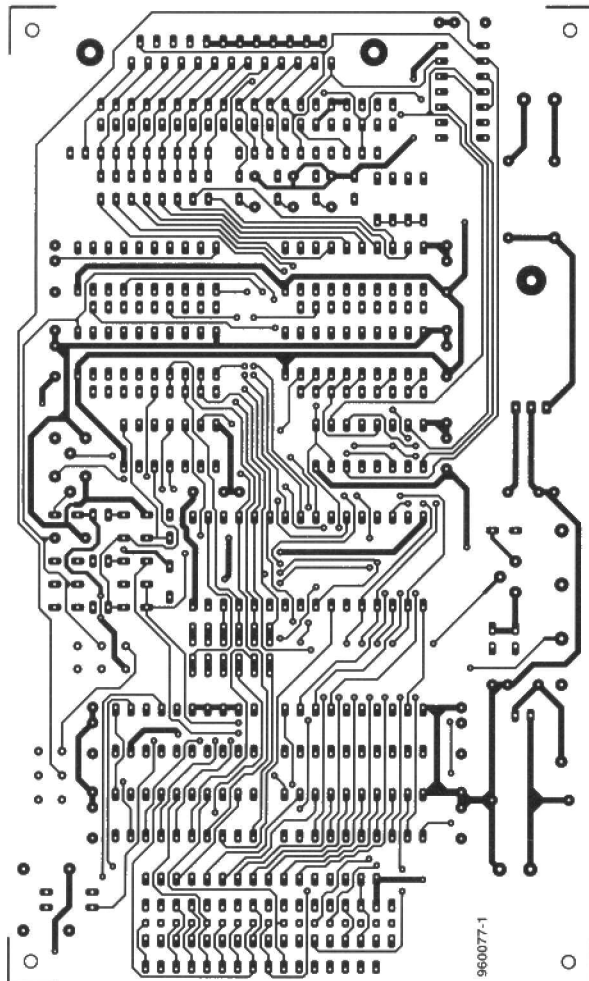
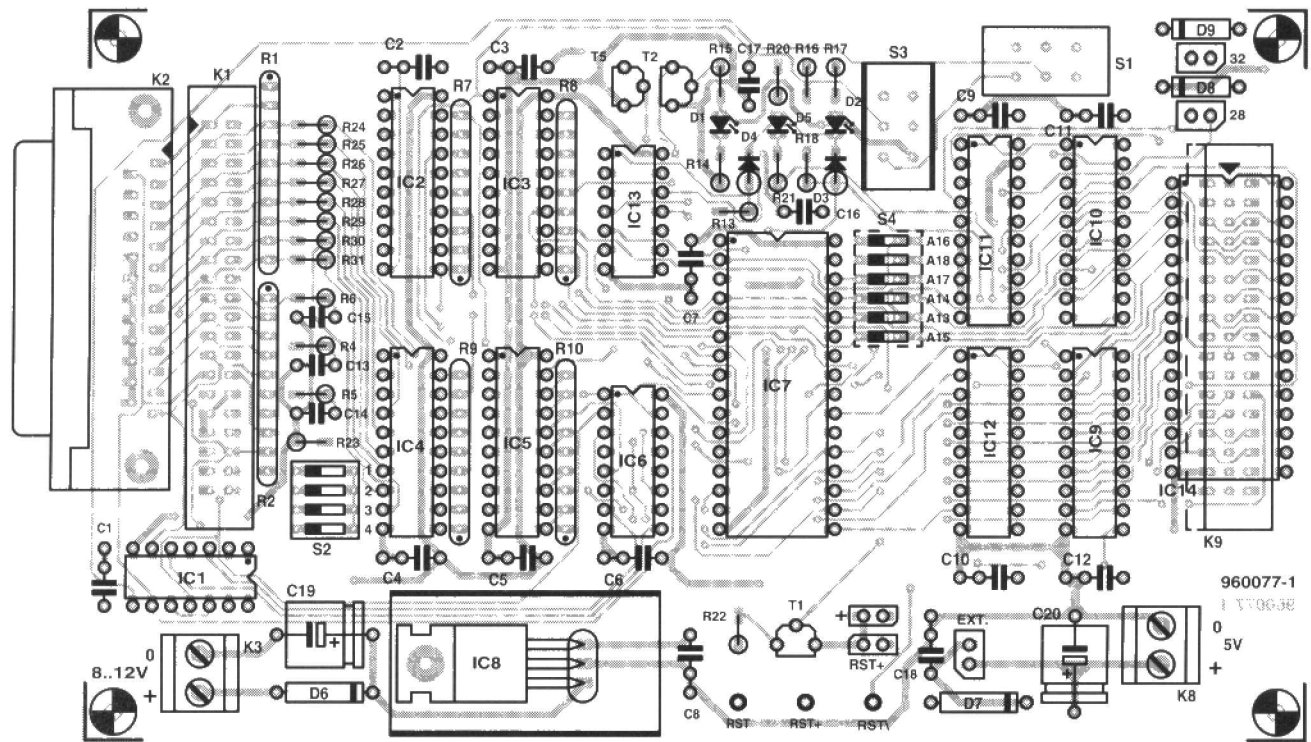


Figure 2. Circuit diagram of the Flash EPROM programmer/emulator. Two 4-to-1 multiplexers reduce the eight-bit wide data bus to only two lines.



[Track layouts shown at 80%]

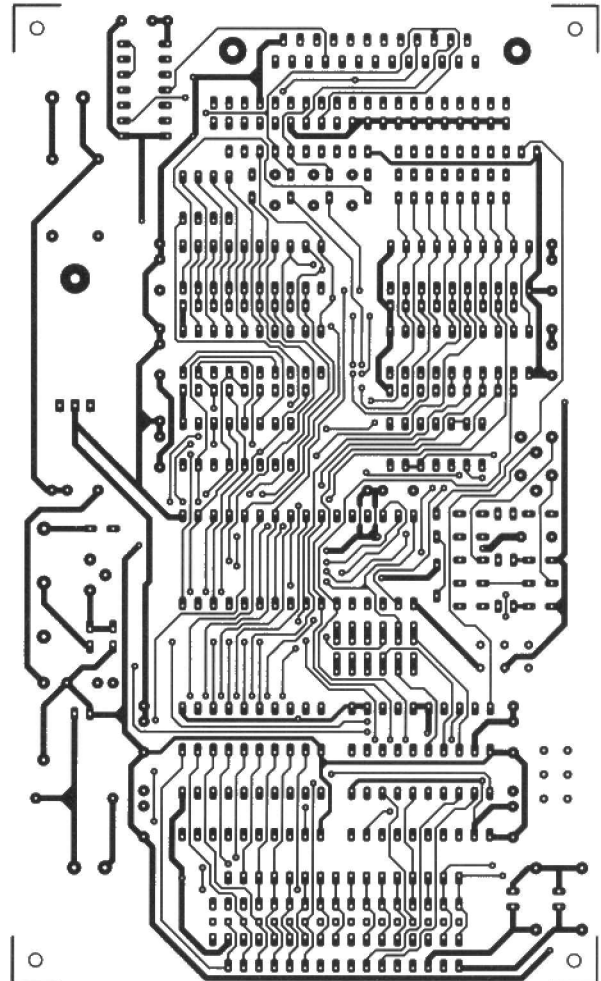


Figure 3. The double-sided board is densely populated and offers a number of options when it comes to linking the board to the PC and the EPROM socket in the host circuit.

CONSTRUCTION

Experienced constructors should not run into problems when building this circuit, most of which will be plain sailing. Special attention should be given, though, to the combination socket for IC14/connector K9. The press-on DIL

connectors come in two different versions: pin 1 = wire 1, or pin 1 = wire 2, so do take care. To prevent difficulties, use the same type of DIL connector at both cable ends. This cable should be kept as short as possible. A (probably) less expensive alternative is to use a

COMPONENTS LIST

Resistors:

R1,R2,R18 = 9-way 3k Ω 3 SIL array
 R4,R5,R6,R13,R24-R31 = 470 Ω
 R7...R10 = 8-way 10k Ω SIL array
 R14 = 220 Ω
 R15 = 2k Ω 2
 R16 = 10k Ω
 R17,R20 = 330 Ω
 R21,R22 = 18 Ω
 R23 = 3k Ω 3

Capacitors:

C1-C12,C18 = 100nF
 C13,C14,C16 = 47pF
 C15 = 100pF
 C17 = 270pF
 C19 = 100 μ F 25V
 C20 = 100 μ F 25V

Semiconductors:

D1 = LED, red
 D3,D4,D8,D9 = BAT85
 D5 = LED, yellow
 D6,D7 = 1N4002
 D2 = LED, green
 T1 = BS250
 T5 = BS170
 T2 = BC547B
 IC1 = 74LS06
 IC2,IC3,IC4 = 74HCT574
 IC5,IC9-IC12 = 74HCT541
 IC7 = 29F040 or 29F010 (see text)
 IC8 = 7806
 IC6 = 74HCT153
 IC13 = 74HCT14

Miscellaneous:

K1 = 40-pin pinheader
 K2 = 25-pin sub-D plug, angled pins
 K3,K8 = 2-pin PCB terminal block
 K9 = 34-pin pinheader
 S1,S3 = (slide) switch 2 x c/o
 S2 = 4-way DIP switch
 S4 = 6-way DIP switch or 2x6-pin pinheader w. jumpers
 32-pin ZIF socket for IC7 (optional)
 2x32-pin DIL flatcable connector with approx. 30cm 34-way flatcable (see text)
 Printed circuit board (960077-1) and software on disk (956017-1), combination order code 960077-C.

pinheader or boxheader at the emulator side. This is fitted either in the solid or the dashed box outline indicated by the component overlay on the board. If you mount it in the solid box outline, the other end of the cable should be fitted with a DIL connector that has a pin 1-to-wire 2 contact arrangement. The second option is for a DIL connector with a pin 1-to-wire 1 structure.

There are also two options for the connection to the PC. The first is formed by pinheader K1, which is connected to an IDC-style Centronics socket via a short piece of flatcable (pin 1 to pin 1). From there, an ordinary printer cable is used to establish the connection with the PC. The alternative is to connect the circuit to the PC via 25-pin sub-D plug K2, for which a 25-way male/female cable is

sufficient (again with pin 1 to pin 1 correspondence).

Depending on the enclosure used and other construction methods applied, it may be worth while to solder DIP switches S2 and S4 at the solder side of the board. That allows the EPROM size and the CE lines to be set with a small screwdriver or similar, without having to open the enclosure. Please note that the cables to switches S1 and S3 should be shorter than 40 mm.

PRACTICAL USE

The programmer/emulator is compatible with the 29F040 and 29F010 Flash EPROM from AMD. Because both have the same command sequences, it is not necessary to make a distinction. Problems may only occur if you try to load a file which is larger than the storage capacity of the Flash EPROM. This is not checked by the software.

Up to four emulators may be connected to a single parallel port. Since most PCs support three parallel ports (LPT1, LPT2, LPT3), up to twelve emulators may be controlled. Resistors R1 and R2 are only fitted in the last emulator! The selection of an emulator on a particular port is carried out via DIP switch S2 (CE1 = first emulator). Address lines may be switched off via jumpers or DIP switch S4 if the EPROM to be emulated has a smaller address range than the Flash EPROM on the emulator. When a switch is opened and the associated jumper also, then the relevant address line is held at a logic low level by a pull-down resistor.

It should be noted that there are EPROMs which expect a logic high level at a non-used pin. If the relevant address line is not properly disconnected with these EPROMs, the emulator will not work as it should. It is, therefore, recommended to always check that all switches and jumpers are properly set, and that all used address lines which are not used by the EPROM to be emulated, are switched off.

Another mistake which may easily occur is an attempt to load hex files. **The software supports binary files only.**

THE SOFTWARE

Control software for the programmer/emulator is available on a diskette which may be obtained through the Readers services. The disk also contains a number of small utilities. Always read the README file on the disk, because it may contain important information which was not available at the time this article was being prepared.

All utility programs on the disk

share a common parameter set, /L<port><ce>. This selects the emulator which is to be addressed by the program. The parameter <port> is either 1, 2 or 3 depending on the LPT port you wish to use. The other parameter, <ce>, is either 1 for CE1, 2 for CE2, 3 for CE3 or 4 for CE4.

An example: the emulator is connected to port LPT2, and switch CE1 is closed. The parameter string then becomes /L21.

The order of the parameters is important to observe with the individual programs. A space should be typed before all file names and parameters!

Flash EPROM programmer utilities:

ERAFLASH /L<port><ce>

erases the Flash EPROM installed in the emulator.

PRGFLASH /L<port><ce> <bin-file>

programs the file <binfile> into the Flash EPROM installed in the emulator. No check is performed whether the file actually fits in the EPROM. If the file size exceeds the memory capacity, the verify routine reports an error.

RDFLASH /L<port><ce> <file> /B<n timer>

reads <n timer> of bytes from the contents of the Flash EPROM installed in the emulator, and copies them into <file>. Because the program does not know the size of the currently installed Flash EPROM, no check is performed whether <n timer> actually fits, or is too large.

Emulator utilities:

LOADEMU /L<port><ce> <bin-file>

The program switches the emulator selected with the /L parameter to 'load' mode, erases the Flash EPROM, loads <binfile>, and returns to emulator mode.

RESETAPP /L<port><ce>

This utility allows you to reset the host (application) circuit via the emulator selected via the /L parameter set. A reset pulse with a length of about 1 s is generated and transferred to the host circuit. (960077)

Note: technical data on Flash EPROMs may be obtained from:

Advanced Micro Devices (AMD) Applications Hotline and Literature, UK and Europe, tel. (01256) 811101.



KEYBOARD SWAP FOR PCs

In some situations, for instance, in education or in process control systems, it is practical to have at least two keyboards connected to a single IBM PC (or compatible, of course). The circuit presented

here enables any PC to be fitted with an extra key-

board, at a small outlay only, and without any kind of internal modification to the computer or the keyboards.



two keyboards on one PC

Having two keyboards hooked up on one PC can be very useful in a number of situations. Such a setup does, however, require that the switching between the two keyboards is fully automatic, and, therefore, 'transparent' to the user. In addition, it would also be nice if the interface for the keyboards could be used in a simple way, that is, without extra cables, difficult settings or software extensions. Last but not least, it would be extremely useful if the interface would accept keyboards with the familiar 5-pin DIN plug as well as types with the compact PS/2 type plug.

For maximum ease of use, and minimum risk of operating errors, it is essential that the circuit always has one of the keyboards selected for a certain

period. In practice, the keyboard swap interface would throw the system in disarray when keyboard 2 is enabled immediately after a key is released on keyboard 1, or the other way around. So, the system discussed here is provided with a certain wait period (approx. 10 seconds) before the second keyboard is connected to the PC again. Despite all the requirements mentioned above, we have been successful in cramming all of the above mentioned features in a circuit containing just two integrated circuits, a handful of passive components, and a few PCB-mount connectors. The conversion from a PS/2 style plug to the more familiar DIN socket is achieved with the aid of a special adaptor plug (which is available commercially) or a home-made cable. Details on this type of adaptor are given in a short inset elsewhere in this article.

SPEAKING OF KEYS...

Keyboards for today's PCs are relatively simple devices. The keyboard interface has four signals on it, irrespective of the connector type. Two pins are used to feed the supply voltage to the keyboard (+5 V and ground). The other two are for the clock signal which indicates whether or not a key is pressed, and for the actual serial code which goes with the key which is being pressed. The clock signal (found at pin 1 of the 5-way DIN socket) is present as long as a key is pressed. Next, the serial data code which belongs to the pressed key appears at pin 2 of the plug.

Basically, there are two types of keyboard in the world of IBM PCs and compatibles: 'XT' keyboards and 'AT' ones. XT keyboards go back to the early years of the PC industry, and are hardly sold any more. All new key-

Design by K. Viernickel

boards supplied these days are of the AT type – search as you may, you won't find XT keyboards any more in the computer shops!

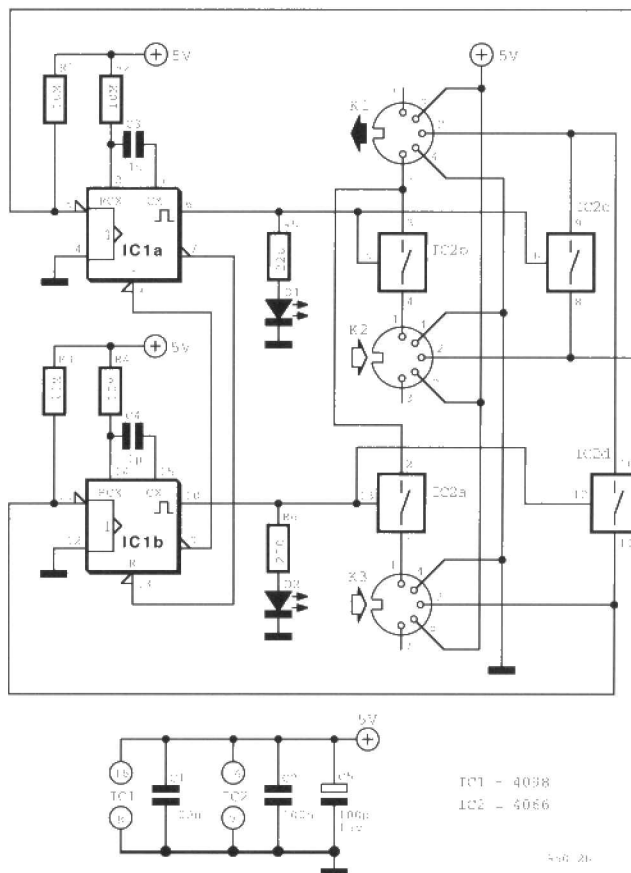
Electrically, the main difference between XT and AT type keyboards is the bidirectional communication which is made possible by an AT-style keyboard. This option is used, among others, to activate the LED indicators (Num Lock, Caps Lock and Scroll Lock) on the keyboard. In an XT keyboard, the LEDs are controlled (i.e., switched on and off) by bistables (flip-flops) which form part of the internal keyboard hardware. In an AT keyboard, this control is taken over by the PC. The communication between the PC and the keyboard, and the associated interrupt processing works properly (in most cases!) when the LEDs on an AT-style keyboard can be switched on and off by the PC.

FROM THEORY TO PRACTICE

The complete circuit diagram of the keyboard swap circuit is shown in **Figure 1**. You will probably agree with us that the circuit has remained pretty simple. Connector K1 is linked to the PC, while connectors K2 and K3 may be used to hook up the keyboards. The circuit contains two monostable multivibrators (MMVs) built around IC1a and IC1b (CD4098). Each of these is set to an RC time of about 10 seconds (by means of R2-C3 and R4-C4 respectively). IC1a is actuated when a key is pressed on the keyboard connected to K2. Similarly, the keyboard connected to K3 actuates monostable IC1b. When a key is pressed, the level at pin 2 of K2 (or K3) changes, and the negative trigger input (–T) of the relevant (retriggerable) monostable is actuated. The logic high level which exists at the Q output of the monostable during the monotime then causes two analogue switches to close (IC1a switches IC2b and IC2c, while IC1b controls IC2a and IC2d). Both switches (for example, IC2b/c) close when the associated Q output is logic high, and then connect the active keyboard to the computer. At the same time, an indication LED lights, so that the user

1

Figure 1. Full circuit diagram of the keyboard swap interface. This circuit enables two keyboards to be hooked up to a single PC.



can actually see which keyboard is currently connected to the PC.

Because the Q output of each of the bistables is crossed over to the RESET

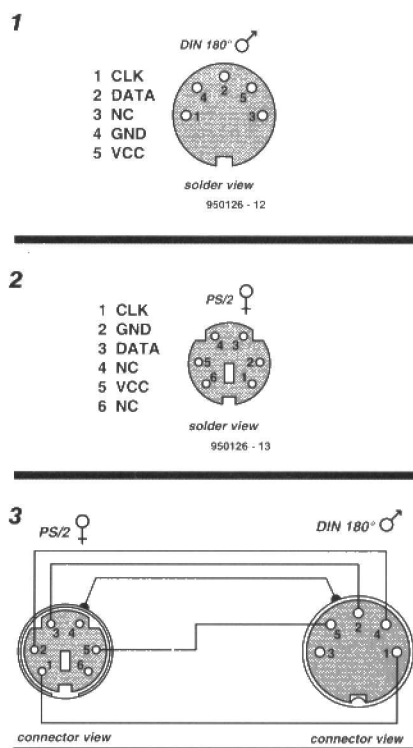
input of the other bistable, the two monostables can never be actuated simultaneously. The non-active monostable can not be actuated until the

From thin to thick

Today's PC market offers keyboards with two types of plug. Traditionally, the 5-way DIN plug is used. A couple of years ago, IBM ('Big Blue') introduced a much more compact connection with their PS/2 line of PCs. Not surprisingly, PS/2-style keyboard connectors are found on many original IBM computers and portables. Although they look entirely different, the 5-pin DIN plug and the PS/2 plug do convey the same signals. An adaptor to bridge the physical differences is therefore easily made.

Figure 1 shows the pinout and pin/signal functions of the 5-way DIN connector. Only four pins are used on this connector: two for the data exchange, and two for the 5-V supply voltage, which originates from the PC.

Figure 2 shows the layout of the PS/2 keyboard connector. Use is made of a compact 6-way mini-DIN plug and socket. An adaptor to link the two standards is easily made from a length of 4-way cable, a PS/2 cable socket and a 5-way DIN plug. Incidentally, these adaptors should be available from any reasonably stocked computer shop.



COMPONENTS LIST

Resistors:

R1-R4 = 4 × 10MΩ
R5,R6 = 2 × 220Ω

Capacitors:

C1,C2 = 2 × 100nF
C3,C4 = 2 × 1μF
C5 = 1 × 100μF 16V

Semiconductors:

D1,D2 = 2 × LED
IC1 = 1 × 4098
IC2 = 1 × 4066

Miscellaneous:

K1,K2,K3 = 3 × 5-pin DIN socket,
180°, PCB mount
Printed circuit board, order code
950126-1

monotime of about 10 s has elapsed on the active monostable. Thanks to this approach, only one keyboard is actually connected to the PC at any time, and cross-interference between the two keyboards is avoided.

THE SOLDER WORK

Figure 2 shows the copper track layout and the component mounting plan of the printed circuit board we designed for this project. The board is available ready-made through our Readers Services (see page 60). Start by installing the two wire links on the board. Next, you may fit the sockets, resistors and capacitors in their re-

spective positions. Observe the polarity of the LEDs when you mount them. It is recommended to use IC sockets on the board. The ICs are fitted last.

All that remains

Figure 2. Copper track layout and component mounting overlay of the printed circuit board designed for the interface (board available ready-made, see page 60). The three DIN sockets are neatly arranged side by side at one edge of the board.

to be done is make the connecting cable to the PC. Via this connection, the circuit is powered by the computer. In practice, the current consumption is very low or even negligible when the two LEDs are out.

It should not be too difficult to find a suitable case for the keyboard swap circuit. The choice is left to you!

The connecting cable is easily made from a piece of four-way cable and two ordinary 5-pin 180° DIN plugs. The connections are not crossed, that is, pin 1 of one plug goes to pin 1 of the other, pin 2 to pin 2, and so on. Fortunately, the pin numbers are usually printed next to the pins, at the solder side.

CONNECTING UP

Use the home-made cable to connect the circuit board to the PC's keyboard input. Next, connect the two keyboards to the sockets on the keyboard swap circuit. Switch on the PC. In case the pre-defined selection time of the monostables (approx. 10 s) is shorter than the boot time of the PC, the computer will probably produce an error report 'Keyboard error, press <F1> to RESUME' or similar. Fortunately, pressing the F1 key on one of the keyboards is always sufficient to complete the 'boot-up' procedure successfully. Both keyboards should now be able to alternately communicate with the PC. From then on, keyboard swapping is only possible when both LEDs are out.

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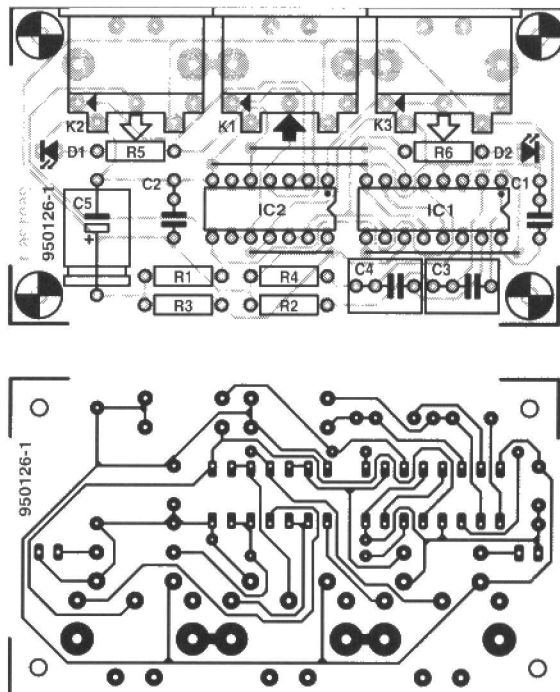
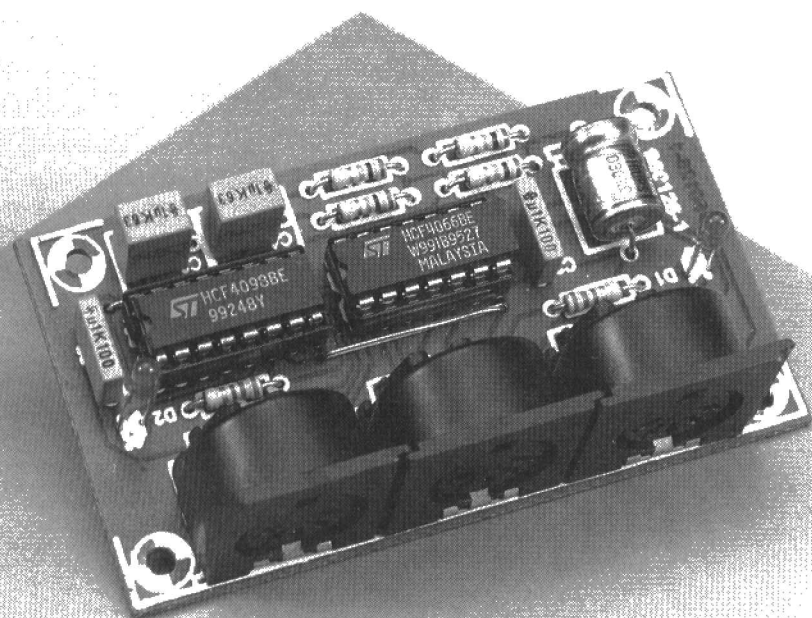


Figure 3. Finished prototype of the circuit, which is connected to the PC via a home-made 4-way cable.

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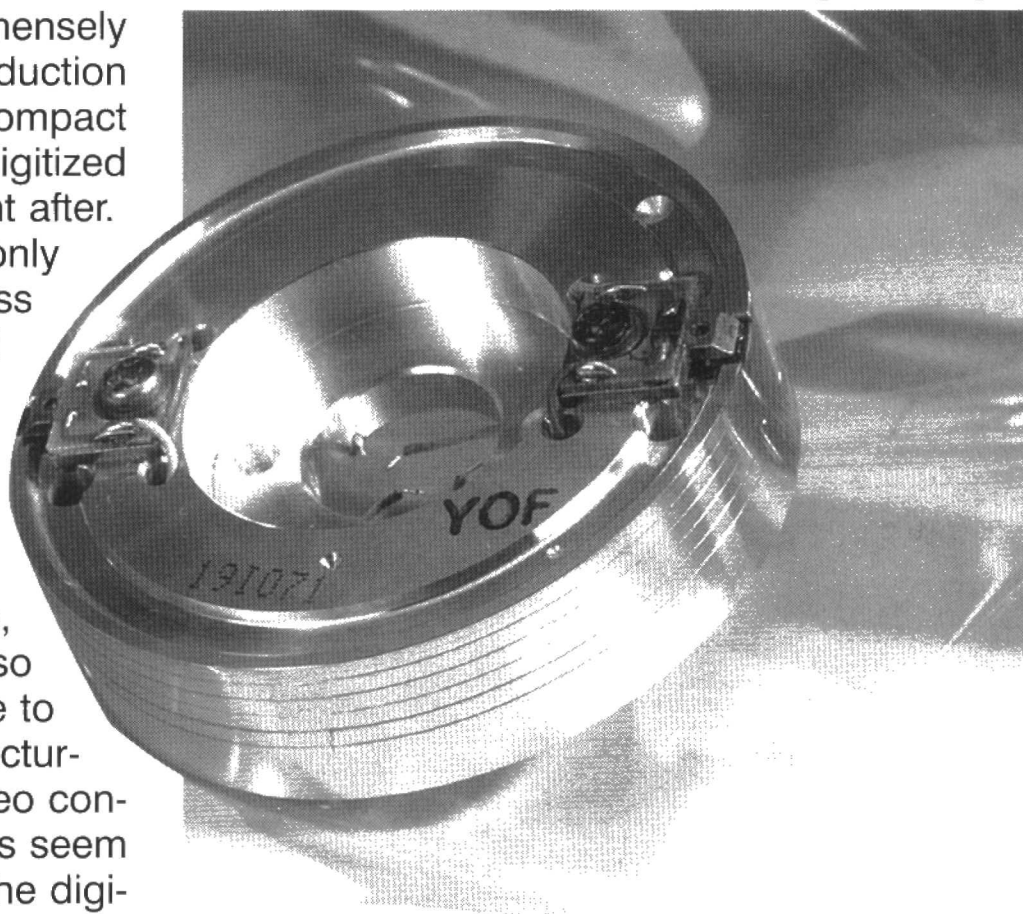
FOCUS ON:

DIGITAL VIDEO RECORDERS

new arrivals every day

Since the immensely successful introduction of the music compact disc, all things digitized are much sought after.

In spite of the only moderate success so far of digital audio recorders like DAT, DCC and the Mini-Disc (which failed to set box office records, and will not do so for some time to come), manufacturers of audio/video consumer electronics seem convinced that the digital video recorder does have the potential of becoming a market 'hit'. All large manufacturers of consumer electronics are highly likely to introduce digital video recording equipment before the end of this year. Let's have a look at what these giants have up their sleeve.



As most of you will know, the digital approach to signal processing has its distinct advantages because it looks upon any event as true or false. Since there is nothing in between true and false, external things like noise signals can not affect the signal quality. In principle, picture signals which have been stored digitally retain their quality for many years. The reproduction of digital signals is still perfect after many years of storage and generations of copies. Also, manipulations of the signals will not degrade the quality, provided these manipulations are carried out in the digital domain.

Leaving the massive impact of digitized audio behind as an accomplished fact, the industry has moved on, and is now at a stage where video signals may be processed digitally, without major problems, in consumer equipment for high-volume production. Digital video standards like MPEG I and MPEG II (which are used with Video CD and digital television), are already applied in practice. It all seems to indicate that the days of analogue video recorder will soon be past, that is, if the manufacturers have their way – as we all know, the market may dictate otherwise.

By our editorial staff

DVIDEO, A WORLD STANDARD

Once bitten, twice shy: having learned their lesson from the problems that arose with the introduction of a standard for the analogue video recorder (once upon a time three different systems, Video 2000, Betamax and VHS contested fiercely for the title 'world standard'), manufacturers of consumer electronics have agreed upon a common standard for digital video. Called DVideo, this standard was the result of the Digital VCR Conference held in July 1993. It is currently supported by at least 52 manufacturers, including all giants like Philips, Sony and Matsushita.

Meanwhile, a number of manufacturers of consumer electronics (including Sony) have started to introduce video systems (camcorders as well as homedecks) which are based on Digital Video.

The new digital video system allows any user to produce recordings and edited work with professional quality using an extremely compact video cassette. The differences between recordings made with the new digital system and the current analogue VHS system are remarkable. The resolution of the digitally stored video image is much higher, and fully retained despite endless copying and editing. The digital recording system also offers many new picture effects and editing options, including sound insertion only, picture insertion only, audio dubbing and video-on-sound. Many picture effects may be employed without modifying the digital recording. A simple computer program and

a serial link between the PC and the recorder are all it takes to actually use these interesting effects.

JVC recently demonstrated that all these features may be integrated into an extremely compact system. Their camcorder type GR-DV1 easily fits in a single hand, yet contains a digital video deck with a plethora of effects and picture editing features, not forgetting a complete camera function, of course. The digital video output enables the digitized video signal to be transferred to another medium (carrier). Most edit functions may be activated directly via the infra-red remote control that comes with the GR-DV1. The price tag is moderate at less than £2,000 right from the introduction.

A NEW CASSETTE, TOO

No new video system to go without a new video cassette, of course. Unfortunately, that means loss of compatibility: in other words, a DVideo recorder cannot be used to play back analogue VHS and 8-mm cassettes.

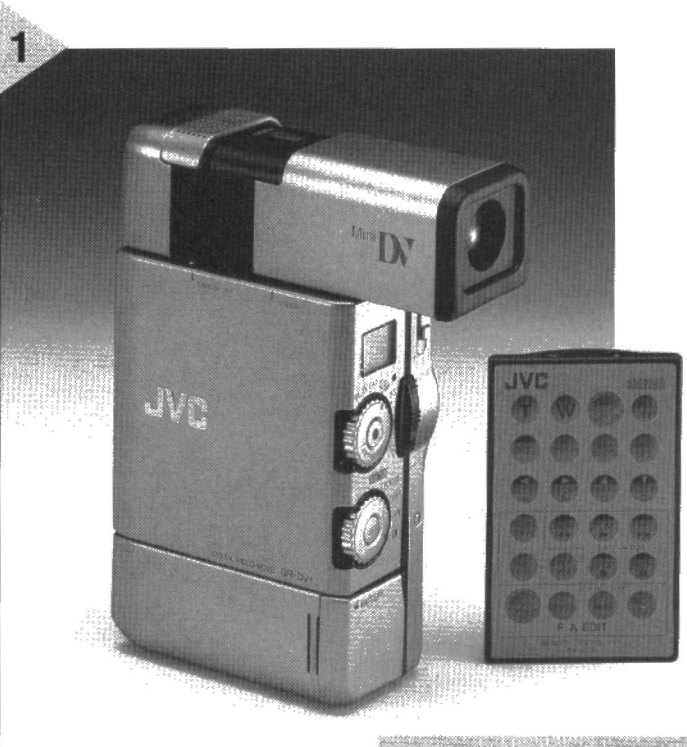


Figure 1. JVC recently introduced an extremely advanced digital camcorder with a built-in DVideo drive unit.

DVideo makes use of two cassette formats, one for station-

ary applications (size 125 × 78 × 14.6 mm), and one for use in camcorders (size 66 × 48 × 12.2 mm). The standard cassette has a maximum play time of 4.5 hours. The mini cassette is available in versions that allow 30 or 60 minutes of digital video to be recorded. The mini cassette is three

and a half times smaller than a VHS-C cassette, and less than half the size of an 8-mm cassette. The big advantage of the new cassette concept is that mini cassettes, too, may be used directly in the home deck. A special adapter as used with the current VHS system is not required.

There is yet another novelty in the video system. In addition to the regular video cassette, there is also a version featuring a separate cassette memory. The useful 'index' function coupled to this memory allows certain fragments to be found faster and simpler. As soon as a cassette with memory is inserted into the camcorder, the relevant index appears in the viewer. With a home-deck, the same informa-

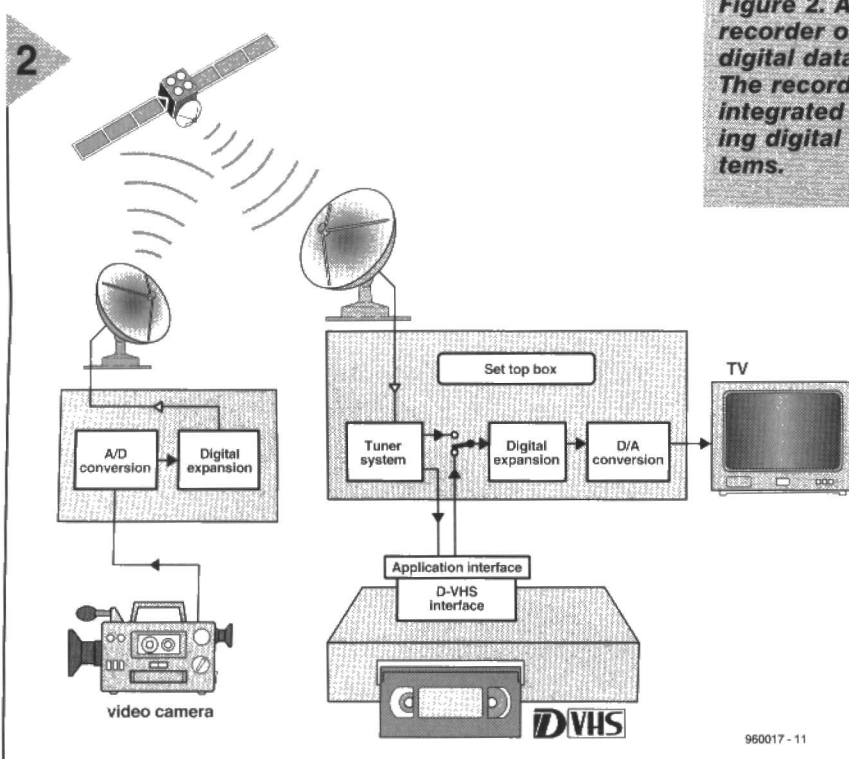


Figure 2. A D-VHS recorder only records digital datastreams. The recorder is easily integrated into existing digital video systems.

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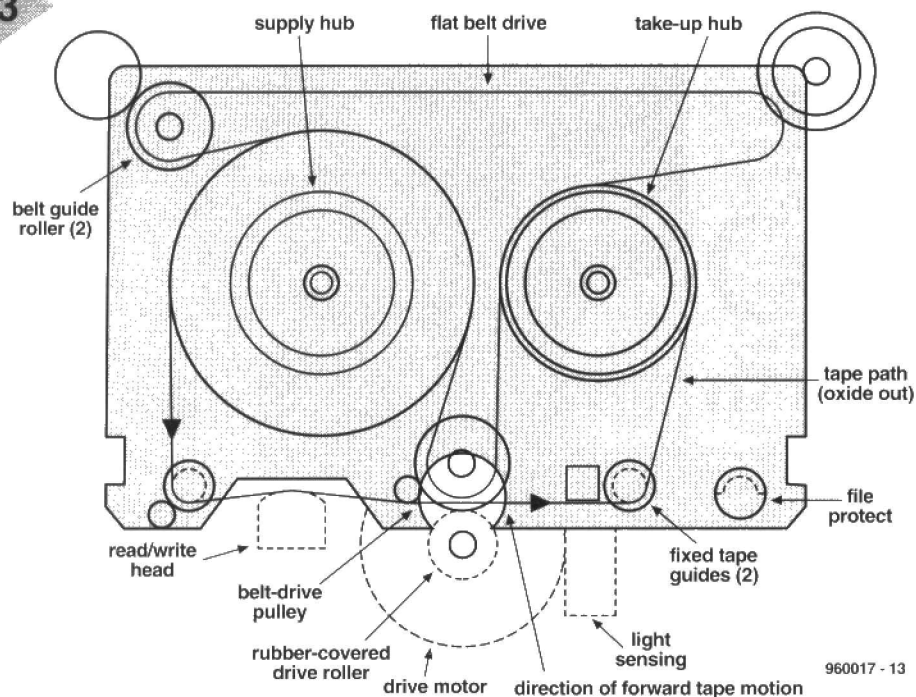


Figure 3. Magnetic recording using the helical-scan principle requires a relatively complex drive unit. Philips are currently researching the possibilities of applying QIC tapes as used in computer tape backup systems.

tion appears on the TV screen.

The tape inside the digital cassette has a width of 6.35 mm, and consists of two magnetic layers deposited on the tape by evaporation. This construction ensures the best possible picture registration. A special diamond-like carbon protection then ensures high durability of the magnetic tape.

DIFFERENT FORMATS

A part of the DVideo standard is a definition of the SD (Standard Definition) as well as the HD (High Definition) format. The SD format has been designed for recording NTSC as well as PAL transmissions. The improvement with respect to analogue recordings is remarkable with camcorders and large-screen displays. The video images are much more lifelike and a lot clearer with large-screen projection. This improvement is due to the fact that Digital Video stores images at a resolution of 500 picture lines. For comparison: up to 250 lines are displayed with VHS and 8-mm recordings, 405 lines with S-VHS, or 420 lines with Hi8.

The HD format offered by DVideo is intended for the recording of High Definition broadcasts. This format is marked by a horizontal resolution of 600 lines, and offers a doubling of the currently used number of picture lines (1,250). Disregarding these resolution

differences, the HD format is identical to the SD format.

D-VHS, A LOGICAL STEP FORWARD

JVC, the inventors of the VHS system, have come up with a digital version, D-VHS, which is to co-exist with S-VHS, the enhanced version of analogue VHS. Meanwhile, other manufacturers including Hitachi, Thomson, Matsushita and Philips are also busy

developing the D-VHS system and making contributions to the technology. Because practically all video recorder manufacturers have shown an interest in this extension of the VHS standard, there is a reasonable chance that D-VHS will be with us in the not too distant future.

The main advantage of D-VHS is that you may continue to use existing VHS tapes, giving the digital video recorder plenty of time to supersede the analogue tapes in a gradual take-over process (JVC reckon this will take at least 15 to 20 years). A D-VHS recorder has no problems playing existing VHS and S-VHS recordings. The price of the digital extension will be around £250. JVC describe D-VHS as 'bit stream data recording'. No compression or expanding of the recorded signal is used. The main aim of D-VHS is the ability to record digital video signals on a magnetic tape. In playback mode, the very same data stream is supplied as the one originally recorded. It is, therefore, not possible to record and play back existing, analogue, TV broadcasts without the help of an external A/D and D/A converter.

As regards its internal construction, the D-VHS recorder is largely similar to present-day analogue VCRs. The same tape path is used in the drive, and the heads that used to record ana-

Figure 4. Experimental set-up in the Philips Physics Lab in Eindhoven, the Netherlands. A regular QIC is used for linear recording of digital video signals.



logue information only are now used to transfer analogue as well as digital information to and from a magnetic tape. The drum rotates at the normal PAL/SECAM speed of 1,500 rpm (1,800 for NTSC), obviating the need to change the speed for analogue recording. Metal tape has also been avoided, S-VHS tape is used in a conventional cassette, but with an additional identification hole to switch the recorder to digital mode.

Three recording modes are proposed: Standard, High Definition and Long play. The first has a maximum input data rate of 14.1 Mbit/s and a recording rate of 19.1 Mbit/s. The difference is necessary to be able to incorporate error correction, which takes the form of the much-used Reed-Solomon code. The modulation system employs the Serial Interface Non Return To Zero Information used in a number of digital systems, such as CD. This system cuts interference by not supplying a signal when it reads a zero. The recording time is 5 hours with a capacity of 31.7-GBytes, or 7 hours and 44.7 GBytes with thin tape. Although the detailed specifications for the HD and LP modes have yet to be decided, the input data rate for the former has been set at a maximum of 28.2 Mbit/s. Tracking is achieved with the aid of a separate track. The first D-VHS recorders are expected to appear on the market later this year. Because the recorder has no in-built provision to convert analogue video signals to digital datastreams and the other way around, the first D-VHS recorders will probably appear in markets where digital television is already widely available. The U.S.A. represent such a market. D-VHS also looks promising for storing huge computer files.

A DIFFERENT APPROACH

Whereas both DVideo and D-VHS are based on firmly established technical solutions like a drive unit with rotating heads, a quite different approach is used by researchers at the Philips Physics Laboratory. Based on the widely used Quarter Inch Cartridge (QIC), a new type of data recorder is being developed which has a stationary head, offering a data throughput of up to 16 Mbit/s. QIC tapes are familiar to computer users because they are used in tape streamers.

With analogue video recorders, the helical scan principle is used to record data on to a magnetic tape. This technique allows a high head-to-tape speed to be achieved. This high speed

is essential to create sufficient bandwidth for the recording of analogue video information. Furthermore, the video signal is recorded in such a way that each track contains exactly one, complete, TV field scan. In a linear video registration system (i.e., a system without a rotating head), all information is transferred to tracks which run in parallel with the tape. Examples of such linear-track systems are the good old audio tape deck and the cassette recorder. The DCC (digital compact cassette) is an advanced version of the linear recorder which reads and writes a large number of parallel tracks with the aid of a head produced in thick-film technology. Because only the tape moves, a linear drive unit has a much simpler construction than a drive unit based on helical scanning.

So far, QICs are only used as backup devices, i.e. for the storage of

record video with a limited picture quality (comparable to VHS). Technologically, it is realistic to expect further miniaturization – eventually, four tracks will fit in the 150 μm which is now used by one data track. This will quadruple the storage capacity from 850 MByte to 3 Gbyte.

With digital video, the throughput rate in the data channel is just as important as the storage capacity. Current research is aimed at a recording density of 0.3 μm per one bit. At a tape speed of 2 m/s that yields a maximum data speed of 6 Mbit/s. Unfortunately, that just happens to be the absolute minimum for high-quality video systems. However, if a multiple read/write head is used with eight parallel tracks, a capacity of 16 Mbit/s is achieved, which is more than enough for high video quality. Real HDTV becomes possible only at 20 Mbit/s and up. In



Figure 5. The first DVideo systems are beginning to appear on the European A/V consumer market. The photograph shows a Sony product.

computer data. The drive and the associated cartridge are inexpensive, compact and stable. QIC tapes usually offer sufficient capacity to enable the contents of a PC hard disk to be archived. Compared with advanced archiving systems such as DAT and 8-mm Exabyte, QIC has a limited storage capacity of about 400 Mbyte. Recently, enhanced versions of this cartridge have appeared on the market, offering a capacity of 850 MByte. The track distance on these tapes being 150 μm , a 0.25-inch tape allows 42 tracks to be recorded. The data recording density is 1.6 bit/ μm , and the tape speed is 1.5 to 2 m/s.

The combination of these features finally results in a maximum data transfer speed of 2 Mbit/s. Because this rate corresponds to the capacity of a data channel for MPEG I video or audio, it is possible to use QIC tapes to

theory, HDTV recording would be possible using multiple heads with more than 8 tracks, or an enhanced tape which requires less than 0.3 μm for one bit.

Towards the end of the tape, the tape speed has to be switched quickly, and the head position changed, so that a new group of tracks may be transferred to the tape, alongside the tracks already recorded. To guarantee an uninterrupted supply of TV images, a buffer is used to compensate the time needed for the switching operation.

Linear registration has yet another important advantage: by adapting the tape speed, the digital bandwidth may be reduced or increased for 'simple' and 'complex' images respectively. Furthermore, the search time is very short indeed. Rewinding a tape completely takes only 45 seconds. Because the head remains in contact with the tape, the recorded material may be viewed all the time.

(960017)



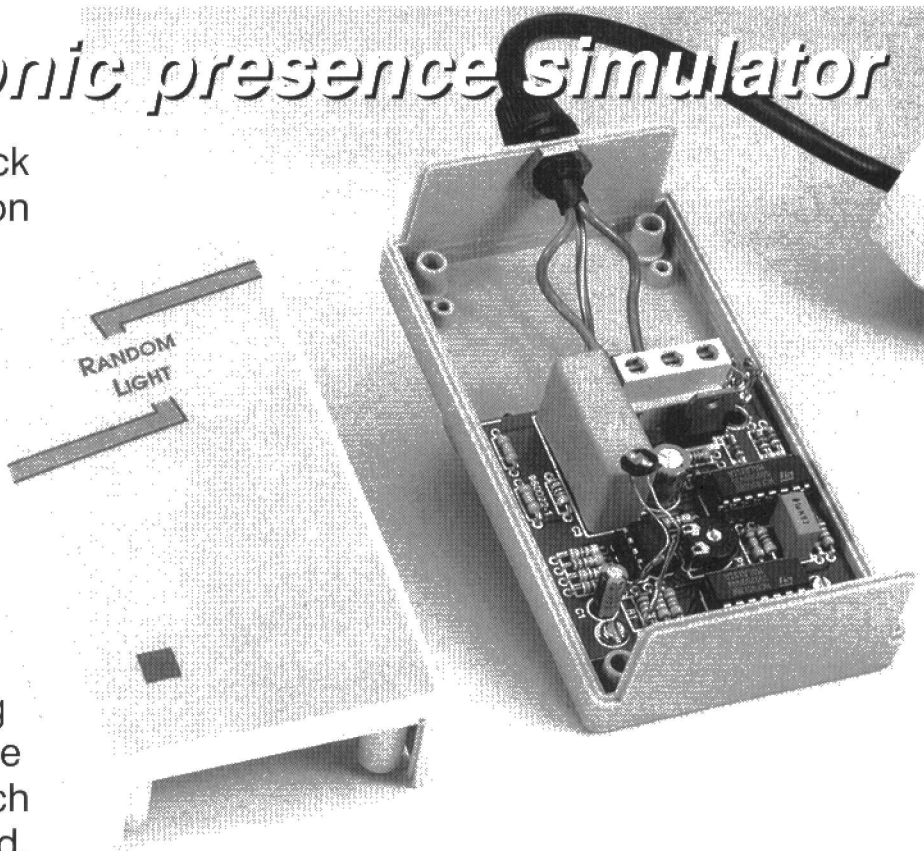
burglar deterrent lighting

an electronic presence simulator

A simple switching clock which keeps one light on in the evening hours when you are not at home is no longer taken seriously as a burglar deterrent. The circuit described here tackles the job of fooling the burglar in a much more sophisticated way by adding a human touch. While traditional clocks switch lamps on and off at fixed, preprogrammed times, the circuit presented here does so at random intervals, providing a realistic suggestion of people being at home.

It is an unfortunate and well-known fact that burglars prefer to break into premises when they have reason to assume that nobody is home. To burglars, the absence of lighting or any other sign of life during the evening hours provides reasonable assurance that they can go about with their nefarious activities for a while. So, using a time-controlled clock which switches on at least one light in the home is not bad for a start to scare off the occasional burglar and petty thief, who will find the risk too great, and look for easier targets.

The matter becomes less simple if the interest of the burglar in question



is more specific. The more experienced members of the burglars fraternity are by no means idiots, and will soon discover the regularity of the on/off switching instants. After some observation, their conclusion will be that a switching clock is being used, particularly, when there is no sign of life in or around the home. To keep this advanced class of thieves out of your home, you need to go one step further as regards effective deterring measures.

The clock described here offers such ingenious operation that even careful observers will be fooled into believing that someone is home. The operation of the control we have in mind is partly the same as that of a regular switching clock: the circuit is activated when it gets dark, and switches on a lamp. After a predefined number of hours, a timer arranges for the control to be switched off again. So far, nothing special. But here comes the clever bit: the lamp is not left on all the time during the predefined period, but is switched on and off at quasi-random intervals.

When used with the light(s) in the reception hall, corridor or staircase, the circuit gives a very convincing im-

pression of people walking about in the home. In practice, this will have a considerable deterring effect against burglars. Moreover, because the circuit is relatively simple and inexpensive to build yourself, this ingenious piece of electronics is highly recommended to all of you who are 'out' a lot during evening hours.

THE SECRET? TWO OSCILLATORS

The above description of the basic features of the burglar deterrent lighting could give the impression that a massive amount of electronic components is required to build the circuit. Not so, fortunately. The block diagram of the deterrent is shown in Figure 1. The actual circuit diagram being hardly more complex, there should be no cause for concern about the size and complexity of the circuit.

Let's have a closer look at figure 1. Where is the ingenious bit? It will be clear that a block marked 'timer', as well as the triac control for the lamp, would also feature in an 'ordinary' switched clock. The novel aspect of the present circuit is the use of two oscillators which work together in perfect

Design by K. Walraven

harmony, and so form the previously mentioned 'quasi-random timer'.

Actually, the operation of the circuit is quite simple. As indicated in the block diagram, there is a marked difference between the output signals supplied by the two oscillators. The upper oscillator has a period of about 1.7 s, while the lower one toggles once every five minutes. The upper oscillator is started by a comparator which measures the ambient light intensity with the aid of an LDR (light-dependent resistor). As soon as it gets

dark, the oscillator starts to supply its output pulses.

The timer is then also started – it ensures that the oscillator is stopped again after a certain number of hours.

In other words, the timer determines the daily period during which the burglar deterrent lighting is active. The length of the period (during the hours of darkness) is adjustable between one and seven hours.

The period of 5 minutes supplied by the lower oscillator determines the rate at which the lamp is switched on and off during the evening hours. That does not mean, however, that the lamp is being switched on and off at fixed intervals of five minutes! The randomness is provided by, among others, a D-type bistable (flip-flop) marked 'FF' in the diagram. The signal sup-

plied by the lower oscillator acts as a clock for this bistable, while the output of the 'fast' oscillator supplies the data signal. As you may know, a D-bistable is a special kind of change-over switch which is operated by its clock signal. Each time the clock signal changes from 'low' to 'high', the level at the data input is copied to the output. However, because that level changes pretty rapidly in this application, it is never certain whether the data input is 'high' or 'low' when the five-minute period of the lower oscillator has elapsed. The result is that there are two possibilities after each period of five minutes: either the lamp is switched on, or it is switched off. Or, rather, four possibilities, because it is also possible for the lamp to remain on or remain off during the next five minutes.

The resulting operation is best described as fairly random: for example, the lamp may first be on for five minutes, then remain off for 10 minutes, remain on for ten minutes, remain off for fifteen minutes, remain on for five minutes, etc. On average, the lamp will be on about half the evening. That may seem rather long for lighting in a corridor or a reception hall, but it is better to

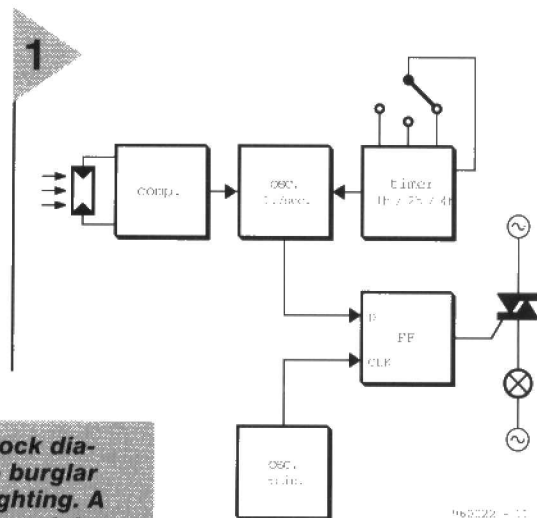


Figure 1. Block diagram of the burglar deterrent lighting. A quasi-random state generator is used to switch a lamp on and off during the evening hours. The randomness is achieved by combining two oscillators.

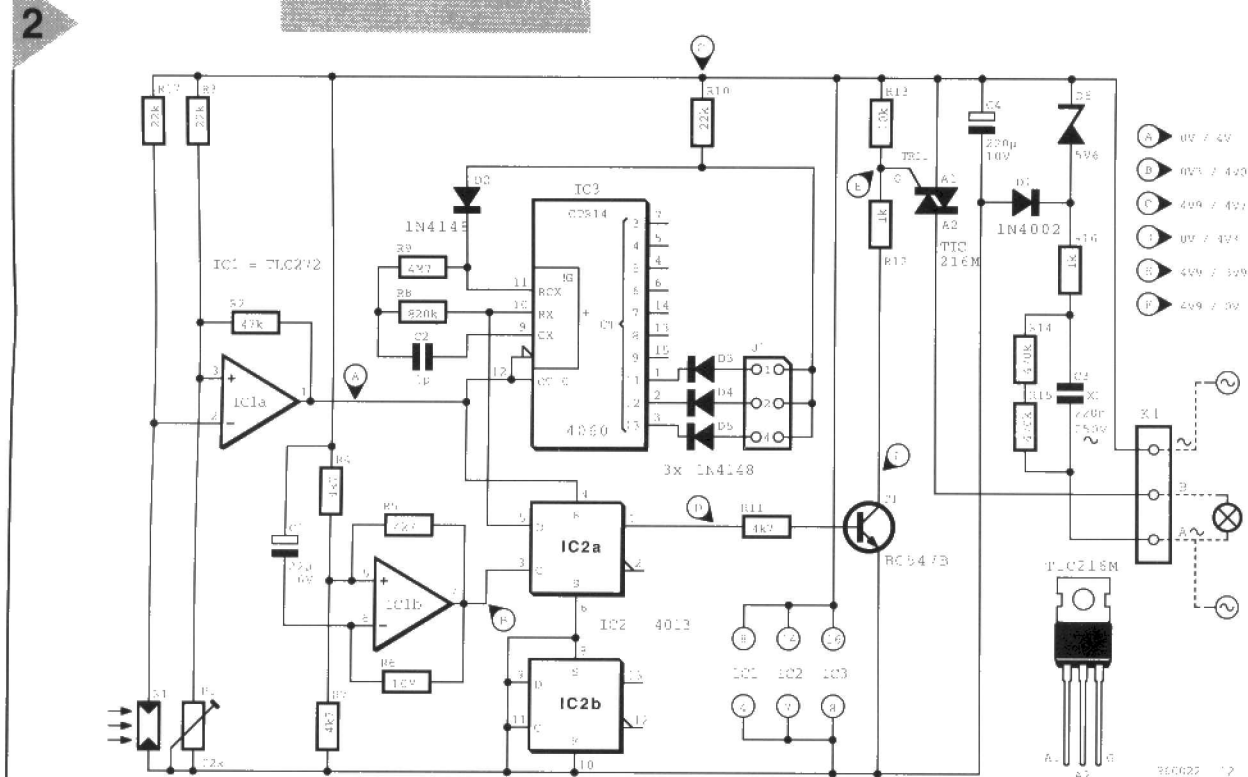
exaggerate a little in this application. Remember, choosing a more realistic rate of about five minutes per hour would increase the likelihood of the deterrent light-

ing not being noticed at all by a potential burglar, who would have no scruples about breaking into your home.

PRACTICAL REALISATION

The schematic in Figure 2 shows you how the block diagram is expanded into an actual electronic circuit diagram. Even at first glance there is a striking similarity with the block diagram. The only marked difference is that the fast oscillator and the hours timer are combined in IC3, an integrated 14-stage binary counter/oscillator type 4060. The other blocks from

Figure 2. This complete circuit diagram of the burglar deterrent allows the blocks in figure 1 to be recognized with ease. The total active time of the circuit is set with three jumpers. The light sensitivity is adjusted once with P1. The mains voltage and the lamp are connected to terminal block K1.



Comparing

Like many other circuits, the burglar deterrent lighting requires the use of a comparator. In most cases, a comparator is actually an opamp with no feedback. In the circuit discussed in this article, opamp IC1a acts as a comparator. When the voltage at the positive input of the opamp exceeds that at the negative input, the output swings high to a level just below the supply voltage. When the other situation exists, the output voltage is effectively at the negative supply voltage, or at ground level. This happens because any voltage difference between the inputs is amplified by an extremely high factor (approx. 30,000 times).

A major advantage of a comparator is that it allows very accurate voltage monitoring to be realized. Simply by applying a (fixed) reference voltage to one input, and the voltage to be monitored, to the other, the comparator will respond briskly when the voltage to be

watched shows up any deviation from the reference. In our circuit, the reference voltage is supplied by potential divider R3-P1. The voltage to be monitored also originates from a potential divider: R17-R1. The latter voltage is light-dependent, because the effective resistance of the LDR is a function of the measured light intensity. Consequently, the output of IC1a will toggle when the resistance of R1 (i.e., the ambient light intensity), exceeds or drops below the threshold set with preset P1.

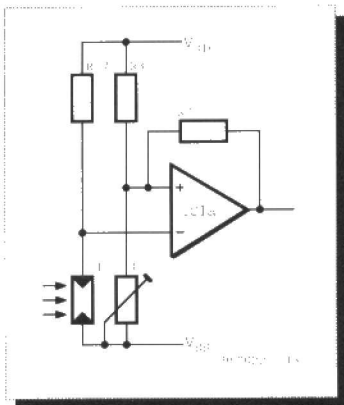


figure 1 are easy to recognize in their practical version. Circuit IC1a acts as a comparator, while the slow oscillator is built around IC1b. The bistable is formed by IC2a.

Although the operation of the circuit should not have secrets by now, the circuit diagram will be explored in the usual way. Light-dependent resistor (LDR) R1 acts as the light sensor. Together with components R3, P1 and R17, it forms an adjustable bridge whose balance determines the output level of comparator IC1a. During daylight hours, the resistance of R1 will be relatively low. Consequently, the output of IC1a is logic high, so that IC3 and IC2a remain reset. When it gets dark, the resistance formed by the LDR rises, causing the comparator to toggle when the threshold set with preset P1 is exceeded. The reset condition is then ended, and the oscillator contained in IC3 is allowed to start working. The length of the period during which the oscillator operates depends on the wire link(s) fitted on the board. The wire links allow the Q11,

Q12 and/or Q13 outputs of IC3 to pull pin 11 of the same IC logic high, thereby disabling the oscillator. The periods set by the wire links are as follows:

- link 1: one hour
- link 2: two hours
- link 3: four hours

Figure 3. The printed circuit board for this project is compact, and easily built up. Mind the polarity of the diodes and the electrolytic capacitors! (board available ready-made, see Readers Services page)

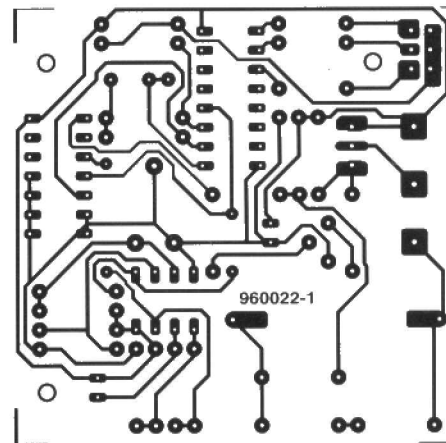
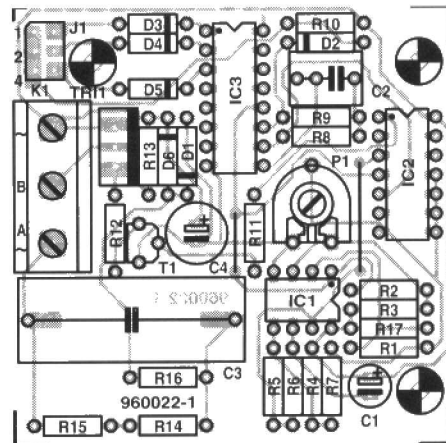
Combinations of these are also possible: for example, fitting both link 1 and link 2 yields a period of three hours. As you can see, any number of hours between one and seven may be set.

The oscillator signal of IC3 is tapped from pin 10 and fed to the data input (pin 5) of bistable IC2a. Note that IC2, a 4013, actually contains two of these bistables. However, because the second one, IC2b, is not required here, its inputs, Set, Data and Clock, are permanently tied to ground. The clock input of IC2a, pin 3, is driven by the output signal of the 5-minutes oscillator. This is built in the simplest possible way from an opamp, IC1b, and a couple of passive parts. Of these, C1 and R6 determine the frequency. Resistor R4 and R7 ensure that the positive input of the opamp is neatly biased at half the supply voltage.

When, after about five minutes, the low-to-high level transition at the output of IC1b coincides with a high level at pin 10 of IC3, the Q output of bistable IC2a copies this high level. Transistor T1 then starts to conduct, causing triac Tri1 to be triggered. The triac in turn switches on the lamp (max. 220 watts). Should the low-to-high level transition at the output of IC1b coincide with a low level at pin 10 of IC3, the Q output of IC2a goes low or remains low, so that the lamp goes out, or remains out. So, a kind of lottery is held every five minutes, with fifty-fifty chances for the lamp.

That really completes our discussion of the operation of the circuit. A few details must be added, though. With a circuit such as the one dis-

2



COMPONENT LIST

Resistors:

- R1 = LDR (small model)
- R2 = 47kΩ
- R3, R10, R17 = 22kΩ
- R4, R5, R7, R11 = 4kΩ
- R6 = 10MΩ
- R8 = 820kΩ
- R9 = 4MΩ
- R12, R16 = 1kΩ
- R13 = 10kΩ
- R14, R15 = 470kΩ
- P1 = 22kΩ (25KΩ) preset

Capacitors:

- C1 = 22μF 16V radial
- C2 = 1μF MKT
- C3 = 220nF 250 VAC (X2-class)
- C4 = 220μF 10V radial

Semiconductors:

- D1 = 1N4002
- D2-D5 = 1N4148
- D6 = zener diode 5.6 V/400 mW
- T1 = BC547B
- Tri1 = TIC216M
- IC1 = TLC272
- IC2 = 4013
- IC3 = 4060

Miscellaneous:

- K1 = 3-way PCB terminal block, pitch 7.5 mm
- J1 = 3-way pin header with 1, 2 or 3 jumpers (wire links)
- Plug-in PSU case
- Printed circuit board, order code 960022-1

cussed here it is practically impossible to avoid the presence of the extremely dangerous mains voltage. It's an unfortunate fact which you can do very little about. The mains voltage is used here for two purposes: firstly, and obviously, to power the lamp, and secondly, to power the control circuit. The latter function is realized in the simplest possible way, by deriving the circuit supply voltage directly from the mains. That is achieved with the aid of a zener diode (D6) and an alternating current resistance, capacitor C3. Resistors R14 and R15 ensure that C3 is discharged reasonably quickly when the circuit is disconnected from the mains. That is necessary to eliminate the risk of an electrical shock when you touch the plug pins.

CONSTRUCTION AND TESTING

That brings us to the practical aspects of the burglar deterrent lighting, in other words, to the construction. The printed circuit board is shown in **Figure 3**. This board is available ready-made through our Readers Services. Before you start fitting components, it is essential to realize that the entire circuit is connected to the mains voltage, and that the construction deserves more than average care to ensure the necessary degree of safety. So, be sure to solder as neatly as you can, and do your utmost to prevent short-circuits.

The board is populated in the familiar order: first, the (isolated) wire links, then the resistors, followed by the IC sockets, the capacitors and, finally, the tallest parts, i.e., terminal block K1, triac Tri1 and capacitor C3. The latter **must** be a high-voltage rated type (250 VAC), and, preferably, an extra-safe X2 version.

It is recommended not to cut the wires of the LDR, R1, until the best position for this device has been established.

Do not insert the ICs in their sockets yet, and first give the populated board a thorough visual inspection. Although the circuit may be expected to work spot-on, some prudence and an extra check are in order here. Do **not** connect the circuit to the mains yet.

Solder two wires to the terminals of capacitor C4, and clip on the probe wires of a multimeter set to the 'DC Volts' range. Temporarily connect a properly isolated mains cable to the outer contacts of terminal block K1. Keep your fingers away from the circuit, and briefly insert the mains plug into the mains socket. The meter should indicate approximately 5 V. Pull the plug out of the socket. Wait a few seconds, then insert the ICs into the respective sockets.

For the sake of security, the remaining checks and test are best car-

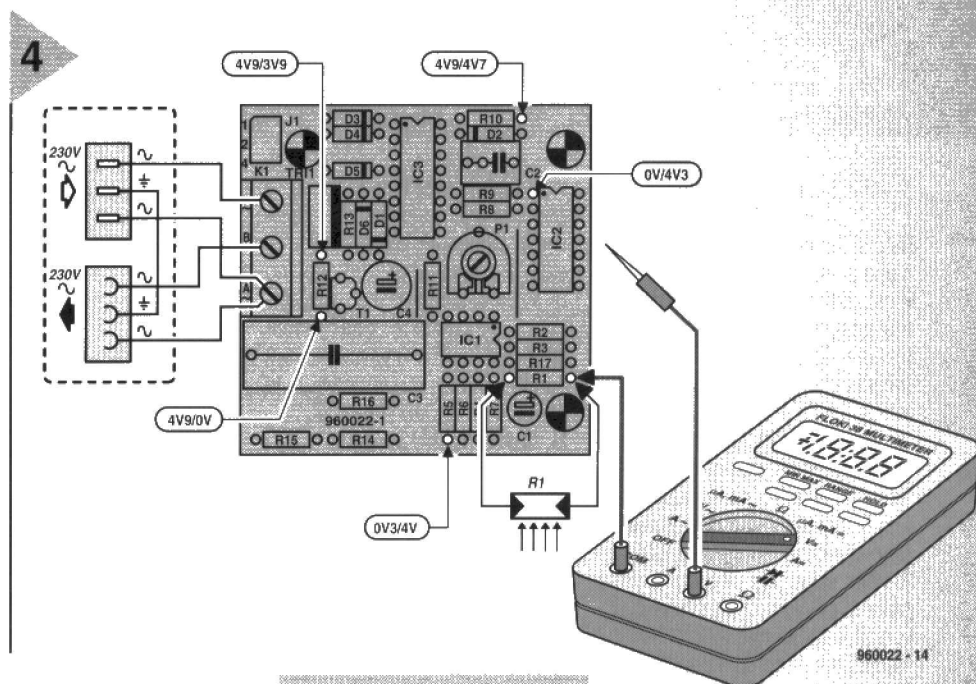


Figure 4. Showing the locations of the various test points in the circuit, and how the board should be wired.

ried out with the aid of an auxiliary supply. This may be a bench-top power supply set to 5 V, or three series connected AA batteries. If the batteries are fresh, you will get sufficiently close to 5 V. The auxiliary supply is connected across C4 (mind the polarity: + to +, and - to -). Switch on, and you may check the voltages indicated in the circuit diagram without the presence of the dangerous mains voltage.

The drawing in **Figure 4** tells you where to find the various test points in the circuit. The negative terminal of electrolytic capacitor C4 may be used as the ground reference for these measurements. Make sure at least one jumper is fitted in position J1. If not, IC3 will remain reset forever.

Initially, the adjustment of preset P1 is fairly uncritical. Generally, it is sufficient to adjust it until pin 1 of IC1a is logic high when the LDR 'sees' light.

The oscillator in IC3 has a period of about 1.7 second. These level changes may be measured at pins 9 or 10. The oscillator will only operate if the LDR has detected a sufficiently high light intensity (even briefly) for IC3 to be reset, after which the light may disappear.

The oscillator built around IC1b has a period of approximately 5 minutes, which may be verified by measuring at pin 7.

FINISHING: THE CASE

The auxiliary supply may be disconnected and put away if the voltage tests give satisfactory results. The circuit then works properly, and may be fitted into a suitable case. When selecting an enclosure, avoid false economy because ruggedness and electrical safety are paramount in this case.

It is recommended to use a so-called plug-in PSU box, e.g. Maplin type BN57M, and mount a mains socket in the cover. If that is

not possible, use a short extension cable and a separate mains socket. The wiring should follow the indications given in **Figure 4**, which shows how to connect the plug, the socket and the terminal block on the board. Do not forget to connect the earth wire between the plug and the socket!

The LDR is mounted such that it can 'peep' outside through a small hole in the case cover. For security's sake, that hole should be covered with a piece of opaque self-adhesive tape. Also, be sure to mount the LDR in a position where it can not detect the light from the lamp.

Assuming that the right jumper(s) is (have) been fitted in position J1, and the sensitivity has been adjusted in the relevant location with the aid of P1, the circuit should really do exactly what is expected to do.

Finally, attach the suggested electrical security label to the case. The power of the lamp connected to the circuit should not exceed 220 watts.

ELEKTOR		
240V~	50Hz	
No. 960022		
P = max. 220W		

Although it was mentioned earlier on in the article, we once more stress that the circuit may need to be started after it is plugged in for the first time. Some light has to be detected by the LDR to enable IC3 to be reset. The next dark-to-light transition then forms the actual start signal!

(960022)

MAINS VOLTAGE MONITOR

(May 1996)

Dear Editor—The above article has a preliminary comment: "In most of the United Kingdom, we are assured of a stable 240 V mains supply voltage." This statement is correct in fact but wrong in law.

In response to the Cenelec harmonization document HD 4772 S1:1988, the mains supply voltage in the United Kingdom has officially been lowered to 230 V. Similar other EU countries will have to raise their official mains supply voltage from 220 to 230 V. (Most have done so—Editor) In the United Kingdom, the change was made in The Electricity Supply (Amendment) (No. 2) Regulations 1994 [SI 1994 No. 3021] which came into effect on 1st January 1995.

In fact, the lowering of the electricity supply voltage has been performed by manipulation of the allowable variation of the supply voltage. Previously (1988 Regulations), the mains supply was required to be within six per cent of the nominal voltage. Under the present regulations the permitted variation is plus ten per cent or minus six per cent. A few minutes with the calculator you are giving to new subscribers will show that 230 volts plus ten per cent is (nearly) the same as 240 volts plus six per cent.

The net result is that the electricity supply organizations can legally lower the supply voltage to a greater extent than before. In practice, as the customer pays for power consumed, lowering the voltage would reduce income and is unlikely. For this reason, the nominal 230 V mains supply will be about 240 V for years to come!

Guy Selby-Lowndes
Billingshurst, West Sussex

Thank you for clarifying the position, which will, no doubt, put many readers' mind at ease.

[Editor]

FROM OPTICAL TO COAX AND VICE VERSA

Dear Editor—The 'Copybit Eliminator Revisited' in your September 1995 issue is based on the conversion of electrical signals only. Some equipment has only an optical input or output. I therefore

wonder whether it is possible to convert digital signals on a coax line to signals on an optical line to enable, for instance, the copying of a digital signal at the coax output of one unit to the optical input of another unit. I have enquired in various shops, but nobody could enlighten me. Can you?

N. Maaswinkel, Belgium.

Your question is answered by 'Splitter for s/pdif coax/optical output' in our July/August 1995 issue.

[Editor]

MAKING GOOD PCBs CHEAPLY

Dear Editor—After experimenting with a number of methods for making PCBs, I have succeeded in developing a procedure that, as far as I know, has not been used before. The underlying idea was to produce a board in fewer steps than is usually the case.

Using a board layout program, I design a layout, or use a layout from your magazine. This is printed on a laser printer with a resolution of not less than 300 dpi on a sheet of satinpaper. (It should also be possible to do this on a standard copying machine, but I have not tried this).

The master board is thoroughly cleaned and sand-papered with a 400 grain (medium fine) paper. Next, the copper side of it is uniformly heated with a blowlamp to about 200 °C. When this temperature has been reached, the toner side of the printed sheet is laid on the heated board and pressed down firmly with a roller. This fixes the toner on to the copper.

Then, keep the board under running tepid water, so that the paper is wetted uniformly. After about 2 minutes, the paper can be removed (carefully!) from the board.

If tiny bits of toner remain on the paper, the corresponding parts on the board can be patched with an etching pen (such as an Edding 3000). When you have tried this method a couple of times, you will find that there is less and less patching to be done.

The board is then ready for etching.

Using this method, I have been able to create tracks of 0.35 mm between the pads for two ic pins.

C. Ates, The Netherlands

We have never heard of this method either, so we are

CONSTRUCTION GUIDELINES

Elektor Electronics (Publishing) does not provide parts and components other than PCBs, front panel foils and software on diskette or IC (not necessarily for all projects). Components are usually available from a number of retailers – see the adverts in the magazine.

Large and small values of components are indicated by means of one of the following prefixes:

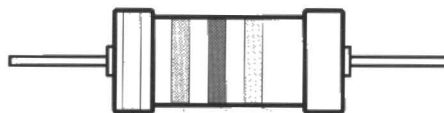
E (exa) = 10^{18}	a (atto) = 10^{-18}
P (peta) = 10^{15}	f (femto) = 10^{-15}
T (tera) = 10^{12}	p (pico) = 10^{-12}
G (giga) = 10^9	n (nano) = 10^{-9}
M (mega) = 10^6	μ (micro) = 10^{-6}
k (kilo) = 10^3	m (milli) = 10^{-3}
h (hecto) = 10^2	c (centi) = 10^{-2}
da (deca) = 10^1	d (deci) = 10^{-1}

In some circuit diagrams, to avoid confusion, but contrary to IEC and BS recommendations, the value of components is given by substituting the relevant prefix for the decimal point. For example,

$$3\text{ k}9 = 3.9 \text{ k}\Omega \quad 4\mu 7 = 4.7 \mu\text{F}$$

Unless otherwise indicated, the tolerance of resistors is $\pm 5\%$ and their rating is $\frac{1}{8}$ – $\frac{1}{2}$ watt. The working voltage of capacitors is $\geq 50 \text{ V}$.

The value of a resistor is indicated by a colour code as follows.



color	1st digit	2nd digit	mult. factor	tolerance
black	–	0	–	–
brown	1	1	$\times 10^1$	$\pm 1\%$
red	2	2	$\times 10^2$	$\pm 2\%$
orange	3	3	$\times 10^3$	–
yellow	4	4	$\times 10^4$	–
green	5	5	$\times 10^5$	$\pm 0.5\%$
blue	6	6	$\times 10^6$	–
violet	7	7	–	–
grey	8	8	–	–
white	9	9	–	–
gold	–	–	$\times 10^{-1}$	$\pm 5\%$
silver	–	–	$\times 10^{-2}$	$\pm 10\%$
none	–	–	–	$\pm 20\%$

Examples:

brown-red-brown-gold = 120Ω , 5%
yellow-violet-orange-gold = $47 \text{ k}\Omega$, 5%

In populating a PCB, always start with the smallest passive components, that is, wire bridges, resistors and small capacitors; and then IC sockets, relays, electrolytic and other large capacitors, and connectors. Vulnerable semiconductors and ICs should be done last.

Soldering. Use a 15–30 W soldering iron with a fine tip and tin with a resin core (60/40). Insert the terminals of components in the board, bend them slightly, cut them short, and solder: wait 1–2 seconds for the tin to flow smoothly and remove the iron. Do not overheat, particularly when soldering ICs and semiconductors. Unsoldering is best done with a suction iron or special unsoldering braid.

Faultfinding. If the circuit does not work, carefully compare the populated board with the published component layout and parts list. Are all the components in the correct position? Has correct polarity been observed? Have the powerlines been reversed? Are all solder joints sound? Have any wire bridges been forgotten?

If voltage levels have been given on the circuit diagram, do those measured on the board match them – note that deviations up to $\pm 10\%$ from the specified values are acceptable.

Possible corrections to published projects are published from time to time in this magazine. Also, the readers letters column often contains useful comments/additions to the published projects.

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ELEKTOR ELECTRONICS 06/95

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FOR SALE: Circuit diagram of capacitance meter for DMM. £ 1.00 Payable by postal or money order or cheque to Raj K. Gorkhali, 5/12 Basamtapur, Kathmandu, Nepal.

pleased to pass it on to other readers. To these readers a warning: be very careful when heating the board—mind your fingers: use kitchen tongs—and consider the fire risk. Without having tried this method ourselves, it nevertheless appears to be an excellent and simple way of producing boards.

Readers should also note that print layouts of projects in the 1995 issues of this magazine – even those not available ready made – may be taken from the CD-ROM that will soon become available. [Editor]

Corrections and Updates

Digital VU Meter - Part 2

(May 1995)

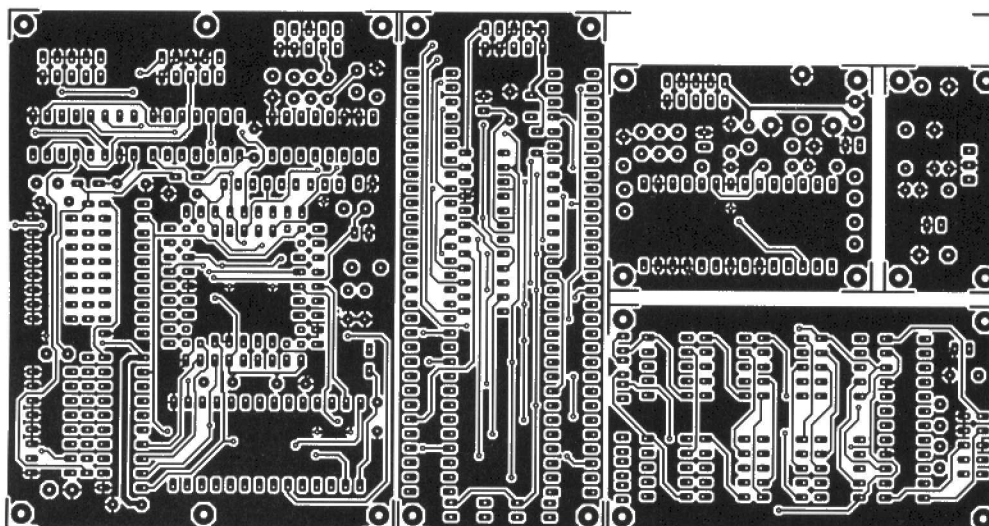
The illustration of the PCB in Figure 3 of this article (page 57) contains an error: the lowest part of the figure is not the

overlay of the component layout; this is now given below. We apologize for any inconvenience this error may have caused.

Satellite Finder
(March 1996, p. 52-55)

In the circuit diagram, Figure 2, the + and - connections of the moving-coil meter, M1, should be transposed.

(960041-1)



950098-1
overlay
missing from May

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ELEKTOR ELECTRONICS

MAY 1996

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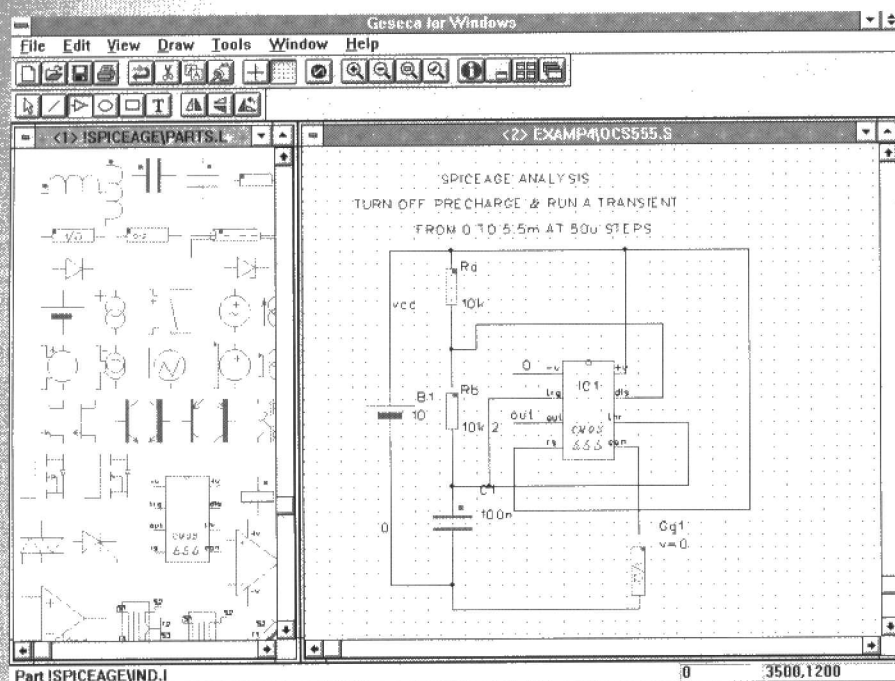
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software for electronics

SpiceAge for Windows



Those Engineers Ltd are regular advertisers in this magazine and well established as developers and suppliers of simulation programs for various electronics applications, ranging from simple filters to complex Smith diagrams. The wonderful software products supplied by Those Engineers certainly deserve to be put in the limelight by means of this column. This month we look at a Spice-like network simulation program called SpiceAge for Windows.

Simulation of electronic circuits is not possible without the help of a powerful computer and some appropriate software. Many programs available in this area are based on the Spice standard are, in fact, further developments of it. Those Engineers apparently left the Spice standard for what it is, and started to develop a simulation program from scratch. Although they obviously did take into account that their product had to be compatible with the Spice standard, SpiceAge has a structure which is markedly different from other Spice programs.

SpiceAge for Windows meanwhile matured into version 5.015 and runs under Windows 3.1 or Windows 95, as indicated by its name. A number of levels are available, ranging from a hobby version with up to 16 nodes to a top-of-the-range version offering 1,800 nodes digital simulation options, Spice primitives and multi-dimensional polynomials. A remarkable feature of the program is its ability to import WAV (wave) files, which may be analysed and used as a signal source. The program also allows you to send the output signals produced by simulated circuits to the soundcard in your PC. In this way you can actually hear the results of your design work!

As with most Windows programs, installing the product is very simple in-

deed. The real work begins once you have the program up and running. You then have to load an existing network file, or enter a new network with the aid of the built-in editor.

The editor assists you during the circuit entry phase by offering buttons that bring up most commonly used components. Double-clicking on such a button pops up a basic line with all necessary details in the netlist, allowing you to enter the relevant values and junctions. Next, an analysis may be run which, depending on the program level you have, enables circuit parameters like quiescent current setting, frequency characteristic, transient response and impedance response to be computed, or a Fourier analysis to be performed on a certain signal.

Countless options are available for the various types of analysis. Of course it is possible to see how the circuit reacts to temperature variations or component tolerances. Likewise, it is easy to have the program do an X-Y plot for you, or create a Lissajous figure.

SpiceAge has a library which comprises most standard components. On top of that, it is possible to build complex blocks that represent a certain component. A number of such blocks are available in the standard library (for example, a 555-based timer).

The higher levels of the program feature a Zetex-Spice library as a standard. This library contains a wide range of transistor and diode models. As a matter of course, it is possible to extend the library yourself – Spice models from semiconductor manufacturers may be used without problems.

BELLS AND WHISTLES

A number of add-on utilities are available for SpiceAge for Windows. One of these is Modelmaker, which allows you to create electrical models of opamps, transformers, attenuators and transistors. Another utility, SuperFilter, calculates and analyzes active, passive, switched-capacitor and digital filters based on a number of user-specified parameters. We found the information received from Those Engineers on this extension interesting enough to put the program on our list of review software for future articles. We will keep you posted.

Finally, there is Geseca for Windows, a graphics entry program for SpiceAge which allows the user to draw a circuit diagram in a simple manner, and then have the program convert it into a netlist. Geseca was supplied with our test version of SpiceAge for Windows. After some experimenting, it soon appeared that

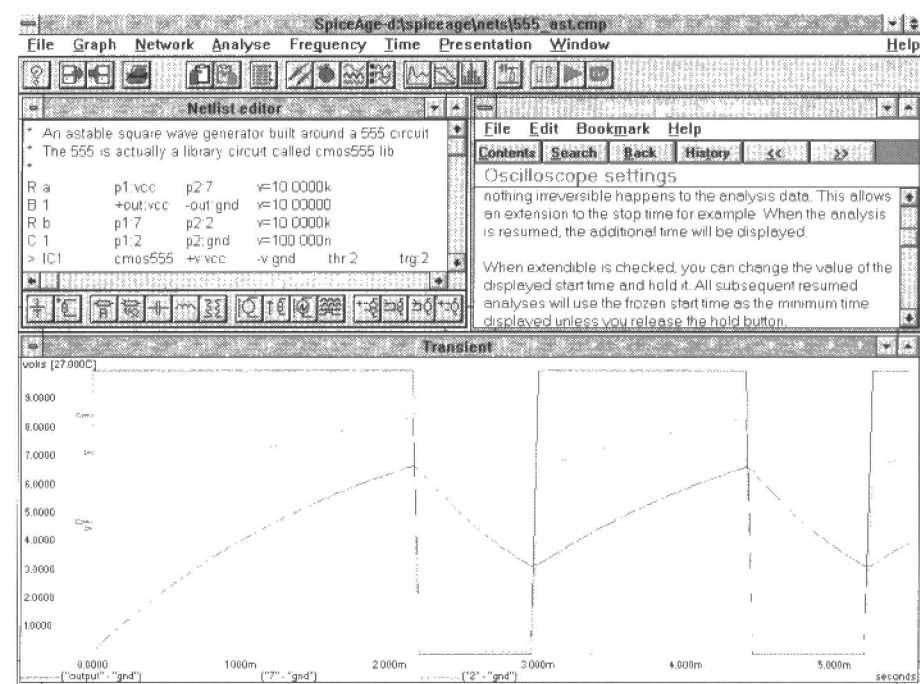
Geseca is really invaluable because the alternative, compiling the netlist manually, is pretty tedious. Potential buyers of SpiceAge are, therefore, well advised to consider purchasing the Geseca extension as well – it is certainly worth the investment.

CONCLUSION

SpiceAge for Windows offers a plethora of options, and during our brief test period we failed to discover anything that could not be simulated by the program. The wide range of available signal sources, simple and complex models, analysis and sweep functions, plot features and additional utilities all help to make this a really complete package from a reputable supplier.

In practice, we also discovered that the program makes good use of all features offered by the modern Windows environment. As such, SpiceAge for Windows sets an example for many competing products.

SpiceAge for Windows and Geseca for Windows form a perfect combination for advanced electronic simulation. Those Engineers have obviously succeeded in producing a remarkably extensive and versatile (but still user-



friendly) simulation program for use on the Windows platform.

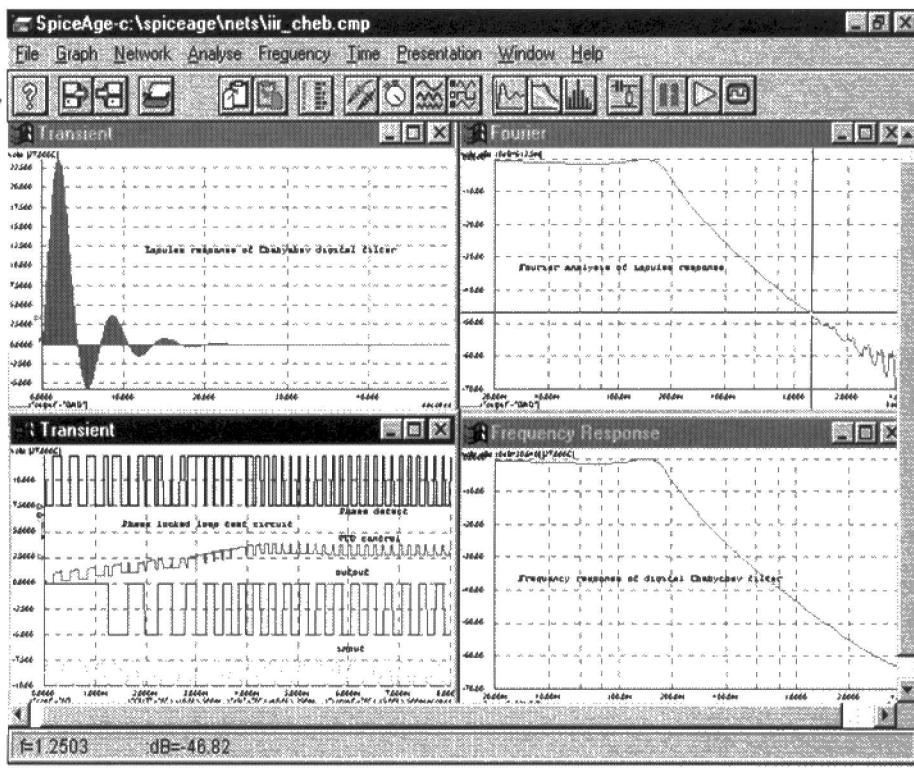
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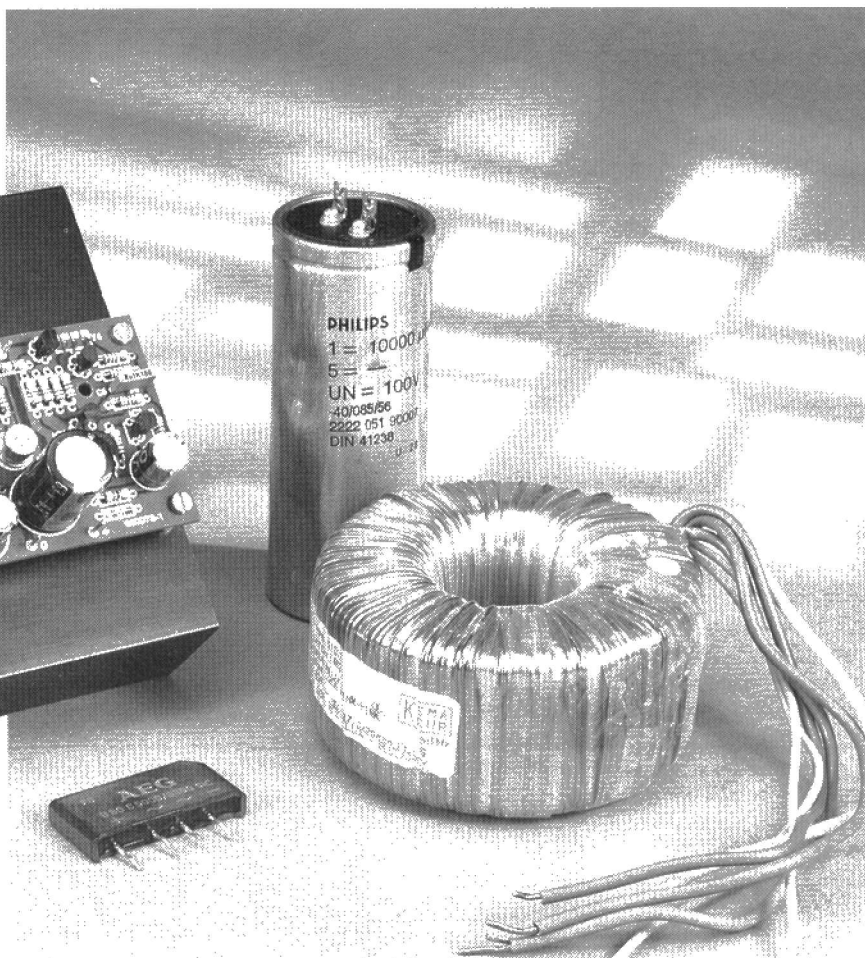
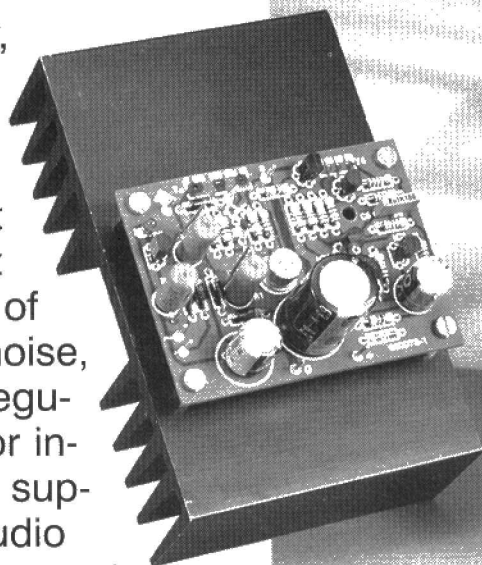


Those Engineers Ltd



active power buffer

Frequently, a direct voltage is required in a circuit that must be free of hum and noise, but not regulated. For instance, the supply to an audio output stage must be able to vary with the mains voltage and the load. Another example is when in the workshop a variable-ratio transformer (variac) is to produce a well-filtered direct voltage with good loading capacity for general purposes.



with temperature monitor

The hum emanating from an unregulated power supply is normally caused by too high a current drain or too small a reservoir capacitor. Enlarging the capacitor is often the simplest, but not always the most effective, way of dealing with the problem. Hum is the manifestation of a ripple on the output voltage and it is best to suppress this in an active manner.

The circuit diagram in **Figure 1** looks like that of a conventional series regulator, but has no regulating amplifier with control comparator. Therefore, the output voltage automatically adapts itself in accordance with the

input alternating voltage and the current through the load. Consequently, the entire hum voltage is applied to the collector-emitter junction of darlington transistor T_3 . The advantage of such an arrangement lies in a drastic reduction of the maximum dissipated power (at the highest mains voltage).

The lower part of the figure is a temperature monitor in which T_4 is the sensor. If this transistor detects an over-temperature, the monitor circuit pulls the base of driver T_2 , and thus that of T_3 , to ground. This effectively cuts off the output current, so that no more power is dissipated.

Design by W. Steimle

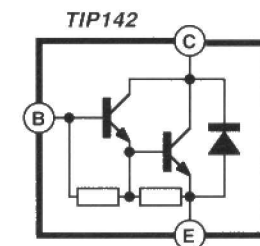
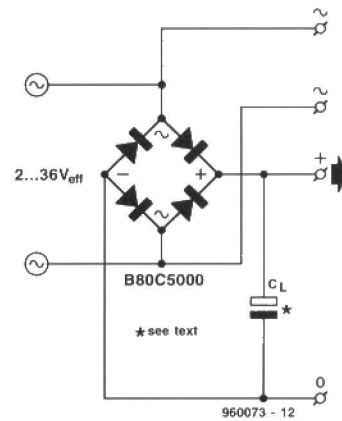
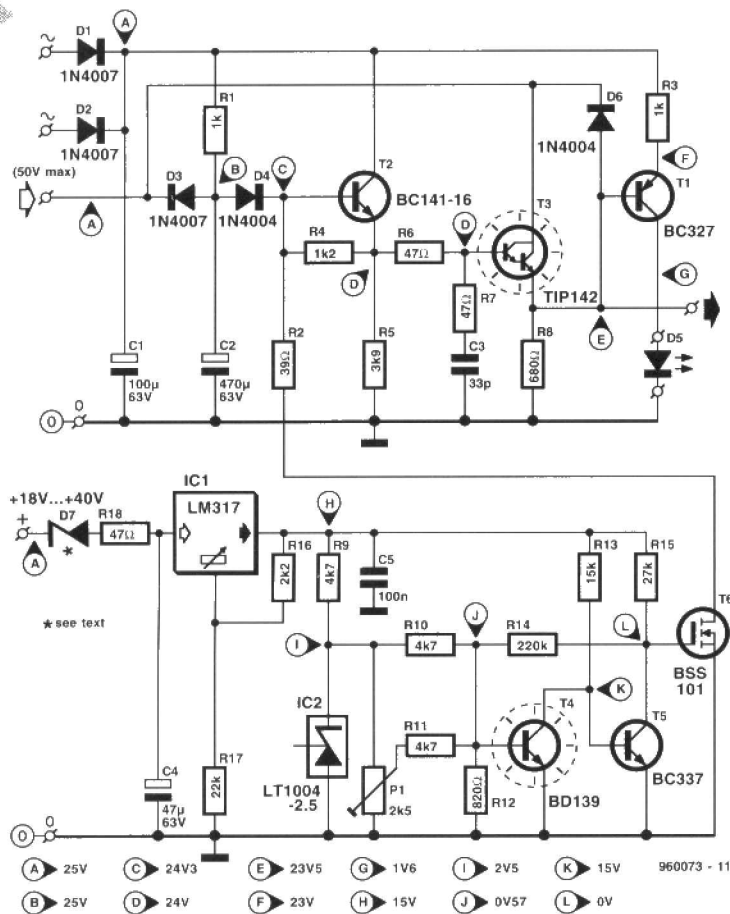


Figure 1. Circuit diagram of the active power buffer, including temperature monitor.

CIRCUIT DESCRIPTION

The circuit is arranged so that the power section (upper part of the figure) and the temperature monitor have their own rectifier. That for the monitor is the bridge rectifier, shunted by reservoir capacitor C_L , while D_1 and D_2 serve the power section.

Whereas the potential across C_L has a ripple whose level depends on the load current, the voltages across C_1 and C_2 are virtually free of ripple, since the load is small. The potential across C_1 is about equal to the peak value of the alternating voltage applied to the bridge rectifier. The voltage across C_2 depends on the minimum level across C_L , $U_{o(min)}$, because it is pulled down by D_3 twice in each mains period to $U_{o(min)} + U_{D3}$. The potential across C_2 , U_{C2} , determines the output voltage, which is about $U_{C2} - 4U_{D3}$.

Diode D_4 is necessary to ensure that U_{CE} of emitter follower T_2 retains a nominal value when the potential across C_1 is a minimum. Resistors R_4 and R_5 ensure that the direct current through T_4 is not too dependent on the current amplification of the transistor and the load current.

Resistor R_1 provides the charging current for C_2 , which must, of course, always be greater than the current

through D_4 and the base current of T_2 . Since the drop across R_1 increases the dissipation of T_3 , the resistor should be kept as small as possible. It should be not too small, however, because at large load currents it determines the ripple on U_{C2} . Its specified value is a compromise between these conflicting requirements.

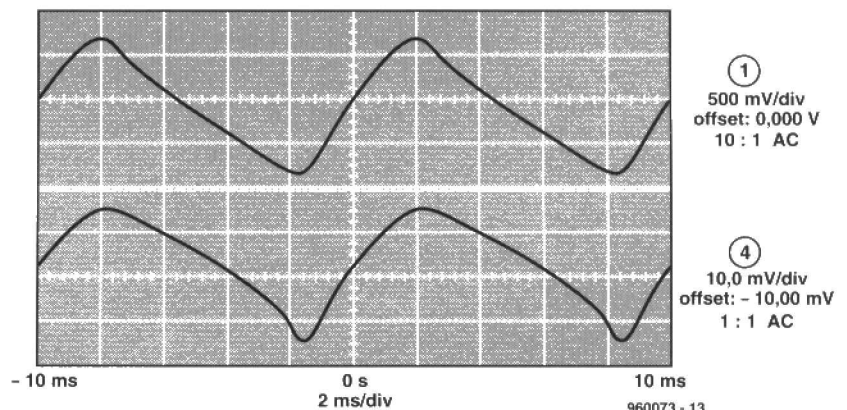
Since the base of T_3 is fed from the inductive output of T_2 , resistor R_6 is necessary to obviate any tendency of the darlington to oscillate. Note that R_7 and C_3 already tend to make the reactance more resistive.

Resistor R_8 provides a minimum load for the circuit.

Resistor R_5 prevents driver T_2 from switching off during the quiescent state when T_3 draws only a tiny base current.

Transistor T_1 draws a current through D_5 , which is more or less directly proportional to the peak hum voltage and inversely proportional to the value of R_3 . This means that the

Figure 2. A 100 Hz hum voltage and the direct voltage at the output that depends on the load current; input alternating voltage is 20.7 V.



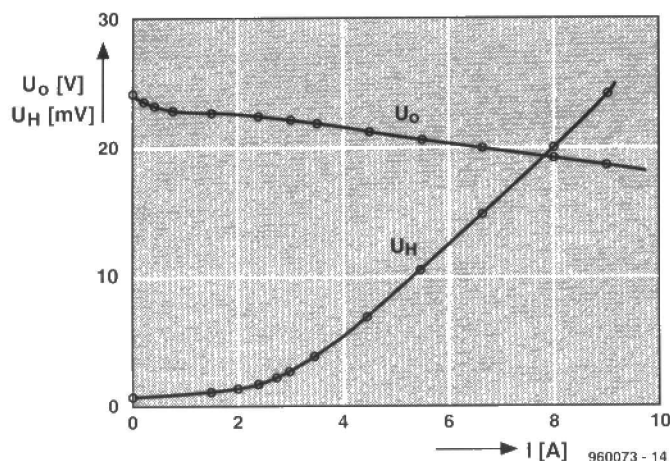


Figure 3. Hum voltage vs time at the input and at the output of the circuit.

brightness of the LED increases with rising load current.

Diode D_6 comes into action only when, for instance, the circuit is being used to charge a battery and the mains fails. The diode then prevents too high a reverse-bias voltage at the base-emitter junctions of T_2 and T_3 .

The output resistance, R_o , of the circuit depends in the first instance on the value of C_L and the peak-to-peak value of the hum voltage, $U_{H(pp)}$, across this capacitor:

$$R_o = U_{H(pp)} / I_o \approx 1/2fC_L$$

where f is the mains frequency. Thus, if $C_L = 10 \text{ mF}$, $R_o = 1 \Omega$.

The residual hum voltage at the output depends on load current I_o . This is shown diagrammatically in **Figure 2**, which assumes an output voltage of 24 V. When the load current is 10 A, hum suppression is about 30 dB. Note that the frequency of U_H is 100 Hz. **Figure 2** also shows the relationship between U_o and I_o . From this it will be seen that $R_o = 0.3 \Omega$.

These measurements were carried out with the input alternating voltage held constant at 20.7 V. In practice, this voltage drops somewhat owing to the internal resistance of the transformer.

Figure 3 shows the hum voltage at the input and output. Note that the hum suppression at peak-to-peak values is about 50, that is, 34 dB, or a little better than previously.

If the average direct voltage at T_3 is made equal to half the hum voltage, the dissipated power, P , is

$$P = U_a \cdot I_o = I_o^2 / 4fC_L$$

Thus, when $I_o = 10 \text{ A}$ and $C_L = 10 \text{ mF}$, the power dissipation is 50 W. Note that this value is independent of the output voltage.

TEMPERATURE MONITOR

For input voltages greater than about 6 V, the circuit is not proof against sustained short-circuits.

It has, however, a temperature monitor which arranges for the load to be disconnected when the temperature rises above a preset level. This arrangement is particularly sensible for occasions when, for instance, the present circuit is used in conjunction with a variac for various purposes when an unwanted overload can happen all too easily.

The sensor is a Type BD139 transistor, which should be mounted on a suitable heat sink. The sensor action is effected by the temperature dependence of the base-emitter voltage, which is easily computed. The sensor and T_5 form a Schmitt trigger with temperature-dependent threshold and hysteresis.

The base-emitter voltage of T_4 is held constant by IC_2 at a value set with P_1 , at which the monitor comes into action when the temperature of the heat sink reaches 85–90 °C. When that happens, T_6 pulls the base of T_2 to ground via R_2 , whereupon T_3 is cut off and the output is open-circuited.

Power for the monitor circuit is derived from a mains adaptor that must provide at least 18 V. It may also be taken from the + terminal of C_L if the potential across this capacitor lies between 18 V and 40 V. If it is higher than 40 V, it is pulled to this value by D_7 . The rating of this zener diode must be such that the voltage at the input of IC_1 remains below 40 V when U_{CL} is a maximum and above 18 V when U_{CL} is a minimum.

CONSTRUCTION

The circuit complete with temperature monitor is best built on the printed-circuit board shown in **Figure 4** (which unfortunately is not available ready made). The two sections of the circuit

are linked on the board by the common earth track at the centre and the connection from T_6 to the base of T_2 via R_2 . If this resistor is omitted, the two sections are completely isolated from one another (apart from the common earth track).

If D_7 is not used, it should be replaced by a wire bridge.

Note that T_3 and T_4 are fitted at the track side of the board. When the board is fitted on to the heat sink as in **Figure 5**, these transistors must be fitted on to the heat sink with the aid of insulating washers, screws and nuts. Two holes are provided in the board near T_2 and T_5 to allow access to the relevant screws.

Connect the ~ terminals from the bridge rectifier to the relevant terminals on the board via light-duty insulated circuit wire, and the + and 0 terminals to the relevant terminals on the board by medium-duty insulated circuit wire.

The buffered output is available at the emitter terminal of T_3 .

INITIAL TEST

The circuit may be tested by checking whether the voltages measured at various points indicated in **Figure 1** coincide with the values shown in that figure. The values were measured in the prototype with an input voltage of 25 V and an open-circuit output.

SETTING UP

The temperature at which the monitor switches off the output is set with P_1 . This temperature is determined by the heat resistance of the heat sink on which T_3 is fitted. If this is 1.8 K W^{-1} , for instance, and the output power is 40 W, the temperature of the heat sink is $1.8 \times 40 = 72 \text{ K}$ with respect to the ambient temperature. The temperature of the power transistor itself is another 40 K above this, so that, when the ambient temperature is 25 °C, it reaches 137 °C. The maximum permissible temperature of the TIP142 is 150 °C.

Set P_1 fully anticlockwise and load the circuit with a power resistor of 0.5Ω , rated at $\geq 32 \text{ W}$ and set the input voltage derived from a variac to such a value that the output current is 8 A (maximum current through the TIP142 is 10 A). If only a fixed alternating voltage is available as input, the load resistance should be chosen to cause a current of about 8 A to flow through it. The voltage at the power transistor depends on the value of C_L , and it is well known that the tolerances of electrolytic capacitors vary widely. Therefore, it is better to measure the collector-emitter voltage and multiply this by the current to arrive at the dissipated power, which should be about 40 W. At this power, the LED should light.

Parts list

Resistors:

$R_1, R_3 = 1 \text{ k}\Omega, 5 \text{ W}$
 $R_2 = 39 \Omega$
 $R_4 = 1.2 \text{ k}\Omega$
 $R_5 = 3.9 \text{ k}\Omega$
 $R_6, R_7, R_{18} = 47 \Omega$
 $R_8 = 680 \Omega, 5 \text{ W}$
 $R_9 - R_{11} = 4.7 \text{ k}\Omega$
 $R_{12} = 820 \Omega$
 $R_{13} = 15 \text{ k}\Omega$
 $R_{14} = 220 \text{ k}\Omega$
 $R_{15} = 27 \text{ k}\Omega$
 $R_{16} = 2.2 \text{ k}\Omega$
 $R_{17} = 22 \text{ k}\Omega$
 $P_1 = 2.5 \text{ k}\Omega$ preset

Capacitors:

$C_1 = 100 \mu\text{F}, 63 \text{ V}$, upright
 $C_2 = 470 \mu\text{F}, 63 \text{ V}$, upright
 $C_3 = 33 \text{ pF}$
 $C_4 = 47 \mu\text{F}, 63 \text{ V}$, upright
 $C_5 = 100 \text{ nF}$

Semiconductors:

$D_1 - D_3 = 1\text{N}4007$
 $D_4, D_6 = 1\text{N}4004$
 $D_5 = \text{LED}$, high-efficiency, red
 $D_7 = \text{see text}$
 $T_1 = \text{BC}327$
 $T_2 = \text{BC}141-16$
 $T_3 = \text{TIP}142$
 $T_4 = \text{BD}139$
 $T_5 = \text{BC}337$
 $T_6 = \text{BSS}101$ (Siemens)

Integrated circuits:

$\text{IC}_1 = \text{LM}317\text{LZ}$ (National Semiconductor)
 $\text{IC}_2 = \text{LT}1004-2.5$ (Linear Technology) or $\text{LM}336-2.5$ (National Semiconductor)

Miscellaneous:

Heat sink 1.8 K W^{-1}
 Insulating washers, screws and nuts for T_3 and T_4

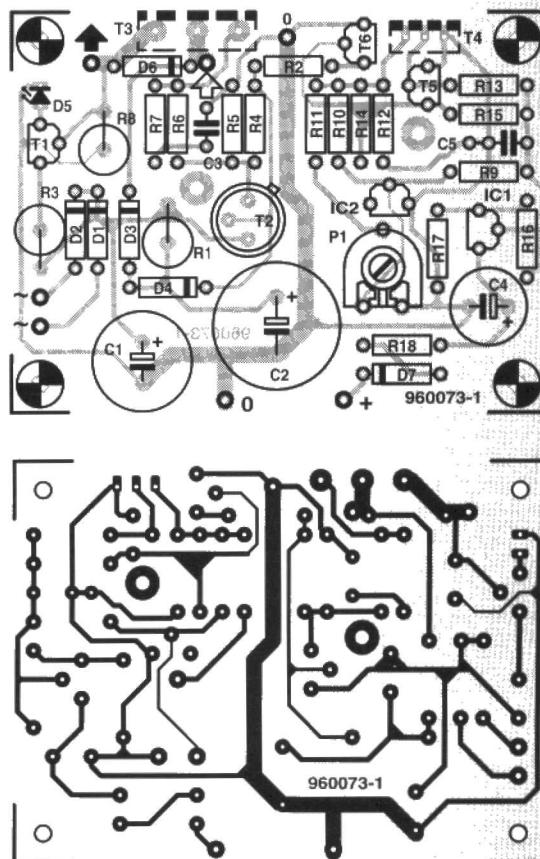


Figure 4. The printed-circuit board for the active power buffer, including temperature monitor.

5

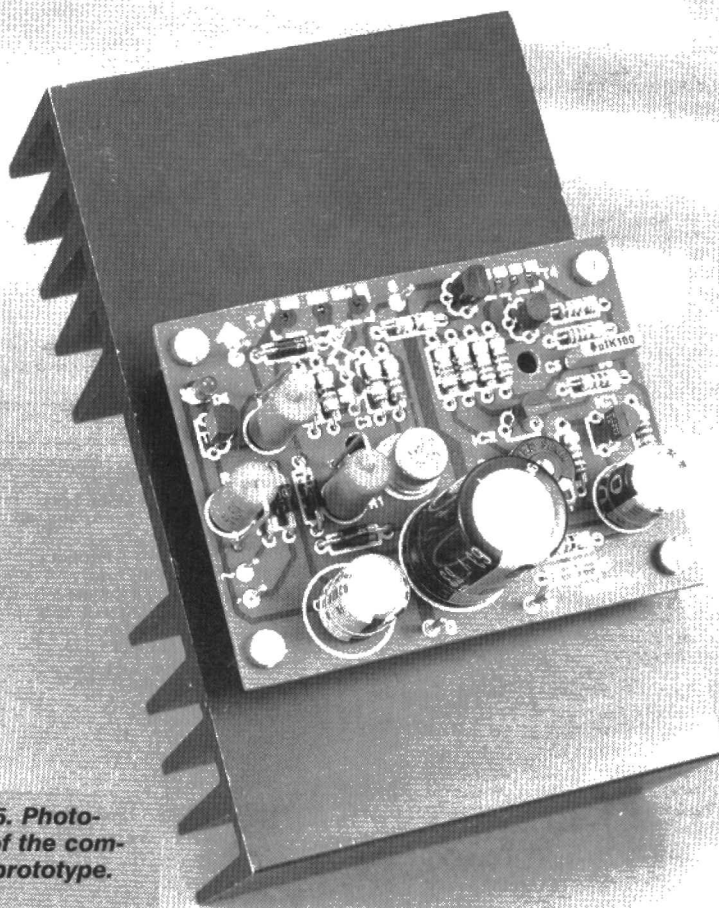


Figure 5. Photograph of the completed prototype.

Wait about 30 minutes, after which the heat sink temperature should be about 72 K higher than the ambient temperature (as computed earlier). It is, of course, better to measure the temperature, but this presupposes that a suitable thermometer is available.

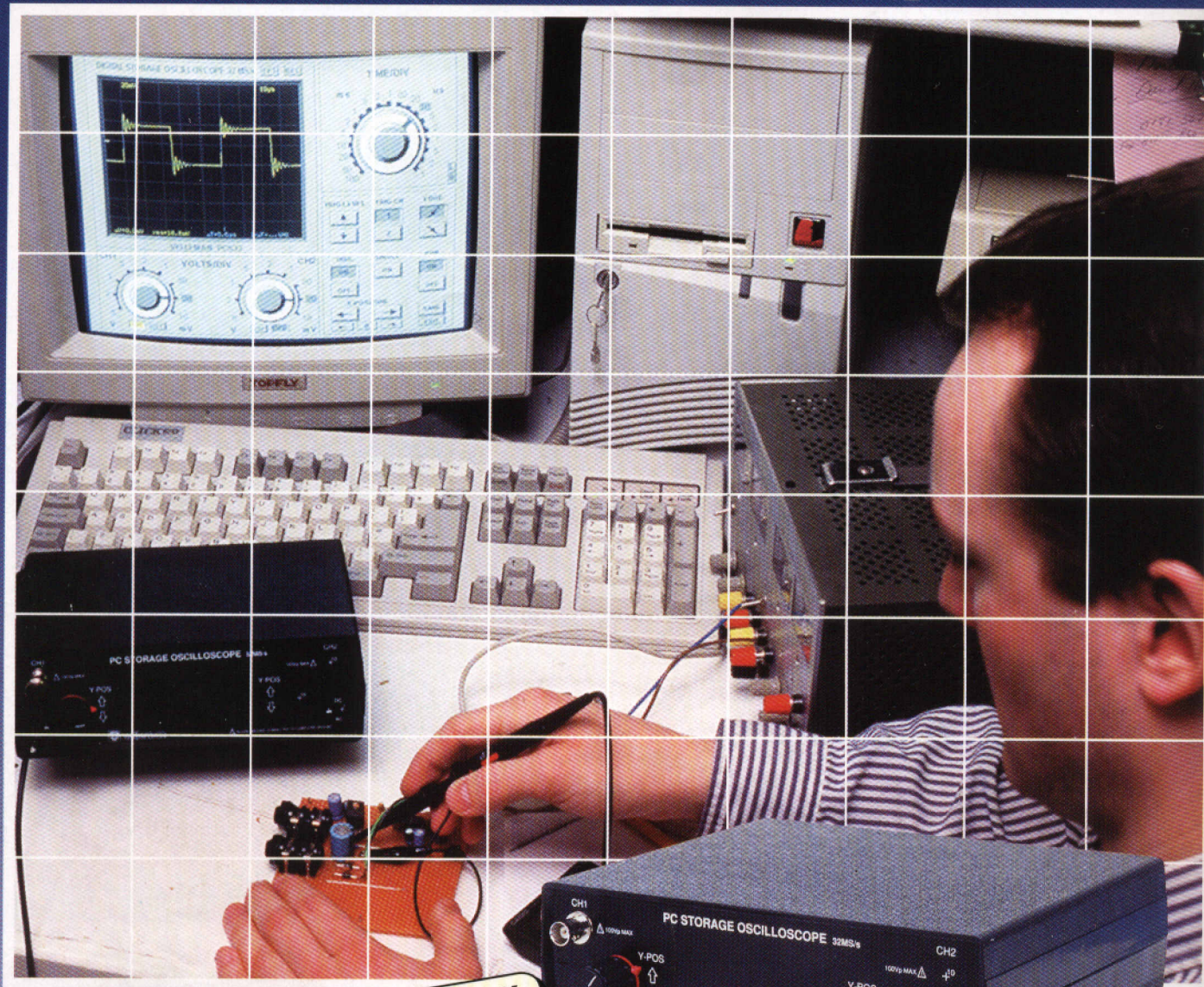
When the stated temperature has been reached, turn the wiper of P_1 carefully clockwise until the LED lights brightest. The monitor then comes into action: the current is cut off and the temperature drops.

Wait a while for the temperature to reach a lower value, when the monitor should be deactivated, and an output current flows again.

Increase the power dissipation slightly and repeat the foregoing. In this way, average cut-off and switch-on temperatures will be set.

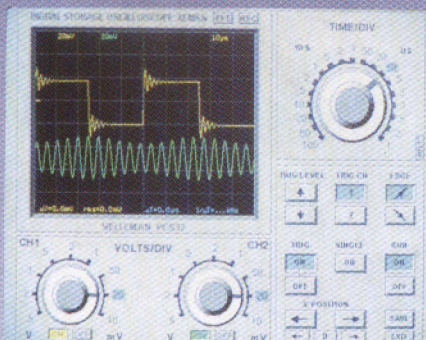
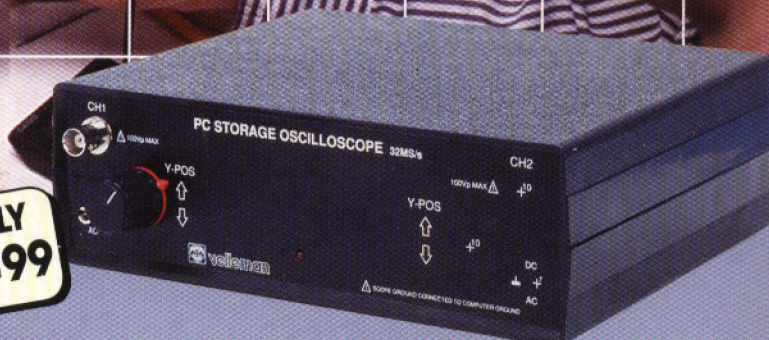
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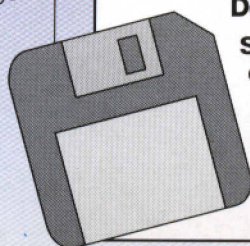
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